CULTURALLY ACCELERATED SEDIMENTATION

ON THE MIDDLE GEORGIA PIEDMONT

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by

STANLEY W. TRIMBLE

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STANLEY W. TRIMBLE

Approved:

________________ Date Dec. 3, 1969
Major Professor

________________ Date Dec. 3, 1969
Chairman, Reading Committee

Approved:

____
Dean, Graduate School

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Date

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INTRODUCTION

As one traverses and observes the middle Georgia Piedmont, a paradox in the physical landscape soon becomes evident. The Piedmont is frequently described as an upland with V-shaped valleys in which streams flow rapidly over rocky shoals. In actuality, many streams of the middle Georgia Piedmont have the characteristics usually associated with the lower Coastal Plain. Valley floors are swampy, and sluggish streams flow over sand beds with little rock visible, either in the channel or on the banks near the stream. In other places, one may see smaller streams flowing in deep trenches with nearly vertical banks of coarse, sandy material. Along nearly all streams are large sand banks, both in the channel and on the banks. One may also see many streams with remarkably straight channels extending for many miles. These straight channels are especially apparent on large-scale topographic maps such as the Pendergrass, Georgia, sheet. Finally, when one searches for certain stream oriented landscape features such as milldams or old bridge piers, it often can be ascertained that the feature is beneath the stream bed. Further, it frequently can be established that the milieu in which the feature was situated has changed greatly in the past fifty to one hundred years. The present valley morphology is indeed puzzling over much of the middle Georgia Piedmont.[1]

Present valley morphology is far different from that found by the first European settlers when they came into the middle Georgia Piedmont during the period from about 1780 to 1805.[2] Most streams then had definite channels. Valley floor land, although often low and subject to overflow, was perennially dry enough in most cases to be cultivated. Bottom land, in fact, has been important for agriculture since earliest settlement of the Piedmont and formed the chief farming area for some Piedmont areas with less level upland.[3]

The middle Georgia Piedmont is, however, an area which is highly susceptible to erosion because of easily eroded soils, steep slopes, and intense rainfall. Some erosion was caused by the initial clearing of land during the early nineteenth century. By the late nineteenth and early twentieth centuries, the steadily decreasing area of forest land and a sharply increasing proportion of land planted in row crops combined with poor soil conservation practices produced erosion and stream sedimentation far greater than the geologic norm.[4] These sediments were chiefly deposited in the headwater streams of watersheds, but all streams underwent sedimentation to some extent. Channels were filled, and valley floors were covered with coarse, sandy, infertile sediment. Often the stream level was raised sufficiently to form wet areas, swamps, ponds, and lakes on the valley floors, thus ruining valuable farm land. Attempts of landowners to deepen and straighten stream channels and drain the adjoining land usually resulted in the rapid refilling of the improved channels.

The beginning of relief from the sedimentation problem came in the 1940's with the reduction of cropland, increased acreage of forests, and implementation of soil conservation measures which greatly diminished erosion and consequent sediment load. In many cases, the increased competence of lower order streams is presently causing the reentrainment and the downstream migration of sediment which had been lodged in headwater valleys. The result of this sediment migration is further change in stream morphology observable at the present time.

Historical Background and Previous Work Relevant to This Study

Man's role in accelerating erosion in the Oconee Watershed was observed by the noted British geologist Sir Charles Lyell in December, 1845, during his second visit to the United States.[5] The first references to significant sedimentation from culturally accelerated erosion were noted in the 1880's, but there was little documentation of sedimentation damage until the beginning of the twentieth century with the advent of the U. S. Department of Agriculture Soil Surveys.[6] Investigators classifying soils on the Piedmont found in many stream valleys large areas of less fertile modern sediment which was so variable in texture and other characteristics that it was impossible to classify in any then-existing categories. Consequently, this modern sediment was classified as "Meadow."[7] These county soil surveys were of benefit to this study in that they conveyed some idea of the local severity of culturally accelerated sedimentation at the time of the survey.

The heavier sedimentary material transported by the Piedmont streams tended to be deposited in and along headwater stream channels, aggrading the stream beds and forming natural levees. Stream overflows became more frequent because of the aggraded channels, but the overflow water was often unable to return to the stream because the natural levee acted as a barrier impounding the overflow water on the valley floor. In some cases, channels were completely filled with sediment so that even the ordinary stream flow spread out over the adjacent valley floor. The result was the rapid transition from productive bottom land to wet or swamp land. In 1911, the Georgia Geological Survey, in conjunction with the U. S. Department of Agriculture, completed a preliminary study of valley land inundated because of sedimentation.[8] This study was followed in 1917 by a far more comprehensive report concerning agricultural land needing drainage.[9] The authors of this 1917 report were aware of the rapidity and magnitude of the changes in stream morphology on the Piedmont, and conjectured as to the cause:

> The general testimony of residents is that in former times the Piedmont streams were sufficient for all ordinary demands made upon them,

> and that overflows were not of common occurrence. Bottom lands now wholly abandoned or cultivated only at great risk formerly were tilled with little expectation of loss by flooding. With the total or partial clearing of the watersheds, and more particularly with the extensive cultivation of the hillsides, drainage conditions were greatly changed. This was due not alone to any increase that, as a result of the clearing, occurred in the percentage of the rainfall that found its way over the surface to the drainage channels, and to the fact that this runoff was more quickly concentrated in the main drainage outlets, but also to marked changes that occurred in the drainage channels themselves as a result of the washing of the soils from the cultivated hillsides into these channels. This latter factor undoubtedly is the most potent cause of the present unsatisfactory drainage conditions in the Piedmont section. There is a difference of opinion among authorities as to whether deforestation aggravates flood conditions by increasing the volume of water to be cared for, but there can be no doubt that the removal of the natural soil covering and the constant exposure of the surface incident to clean cultivation, facilitates soil erosion, and it is equally true that these products of erosion ultimately will find their way into the main drainage channels.[10]

Thus, investigators of the early twentieth century recognized that the extensive acreages of clean-cultivated crops were responsible for accelerated erosion and the consequent sedimentation. They also recognized the rapidity and magnitude of the changes in valley morphology as a result of accelerated sedimentation.

Attempts were made by land owners to drain these wet lands by straightening and deepening (ditching) the clogged streams, but these expensive endeavors were largely unsuccessful. The U. S. Bureau of the Census made surveys of agricultural drainage projects in 1920, 1930, 1940, 1950, and 1959, but these surveys were incomplete.[11] There are no complete records of these drainage projects available, but their imprint is still strongly imbedded on the landscape in the form of anomalously straight channels.[12]

No other studies of culturally accelerated sedimentation on the Georgia Piedmont have been located in the relevant bodies of literature examined during the course of research on this thesis. A study of sedimentation in the South Carolina Piedmont, however, was made by Stafford C. Happ in 1945. Happ found that approximately 180,000 acres, or approximately three-fifths, of South Carolina Piedmont bottom land had been made unsuitable for agriculture because of culturally accelerated sedimentation.[13] This study of culturally accelerated sedimentation in the South Carolina Piedmont was of especial interest because the phenomena examined were very similar to those found in the middle Georgia Piedmont.

General Documentation of Culturally Accelerated Sedimentation

Culturally accelerated sedimentation is widespread throughout the United States and the world and has been taking place for thousands of years.[14] In the United States, European man has been accelerating the processes of erosion and sedimentation to significant proportions since at least as early as 1750.[15] In the eastern United States during the last half of the nineteenth century, there were increasing numbers of scattered reports of streams filling with sediment and a veritable flood of reports by the beginning of the twentieth century coinciding with the vastly increased pressure on Agricultural land, especially in the southeastern United States.[16]

With the inception of U. S. Government soil conservation programs in the 1930's, notably those of the Soil Conservation Service, more accurate and scientific information concerning erosion and sedimentation became available. Especially valuable are U. S. Department of Agriculture Technical Bulletins, Circulars and Technical Pamphlets, and U. S. Geological Survey Water Supply Papers, Bulletins and Professional Papers. Valuable sources for individual states are publications of state agricultural experiment stations and of state geological surveys.[17]

A survey was made in the middle 1930's of sedimentation damage to lakes and reservoirs in the Southeast. The results of this study, published in 1936, showed that most reservoirs were significantly reduced in capacity and many smaller reservoirs completely filled with sediment. The theorized reason was culturally accelerated erosion and sedimentation.[18] In 1940, Stafford C. Happ and associates published a comprehensive study, "Some Principles of Accelerated Stream and Valley Sedimentation."[19] This study, a synthesis of available information and extensive field research in the Southeast, was a scientifically rigorous and thoroughgoing examination of accelerated sedimentation. It culminated in a set of forty-five principles or statements of fact concerning accelerated sedimentation. Happ concluded in part that:

> Accelerated stream and valley sedimentation is much more widespread and progressive accumulation is taking place much more rapidly than has been commonly realized either by the general public or by specialists in allied fields of scientific inquiry. The past and prospective future damage resulting from such sedimentation is of sufficient importance to be of national concern. Damage has been of many diverse kinds, but so far as is now known the most important have been (1) impairment of the productive capacity of agricultural valley lands by changes in soil texture, composition, or drainage, (2) aggravation of flood danger and flood damage by filling of channels and aggradation of flood plains with consequent increases in height and frequency of overbank floods, and (3) impairment of the effectiveness or usefulness of artificial structures and improvements.[20]

Because of its comprehensive coverage of the processes and effects of culturally accelerated sedimentation, the 1940 Happ study was one of the most valuable documents consulted in the present study.

The study of culturally accelerated erosion and sedimentation was given further systematic treatment in 1956 by Arthur N. Strahler in his essay "The Nature of Induced Erosion and Aggradation."[21] In this study, which relied entirely on secondary sources, Strahler attempted:

> . . . to synthesize the empirical observations of the engineer on particular cases and in restricted physical limits with the more generalized rational theories of fluvial erosion and deposition formulated by the geomorphologist, who views landforms as parts of evolving systems adjusted to given sets of environmental factors.[22]

There appears to have been little work done in the field of culturally accelerated sedimentation since the mid 1950's.[23] There has, however, been much research on erosion accomplished by the U. S. Department of Agriculture. The result of this research has been the determination of erosion factors and their relative importance.[24]

The concept of man's having the leading role in accelerating erosion and consequent sedimentation is either stated or implicit in every study consulted. What was conjecture derived from empirical research in the early part of the century has been scientifically corroborated in mid-century. G. M. Brune, for example, found that when cultivated or "idle" land in a watershed is increased from one-third to two-thirds of the total area, the sediment load in the runoff is increased six and one-half times. This sediment load is increased thirty-five times when more than two-thirds of the drainage area is cultivated or "idle."[25] Leopold, a geomorphologist, also mentions several other similar studies in his essay, "Land Use and Sediment Yield."[26] Strahler noted by 1956 that:

> Apparently nearly everyone accepts the severe gullying of the Piedmont and of the Middle West loess regions as an example of accelerated erosion brought about by man.[27]

There are, of course, other erosional factors such as soil types, amount and intensity of rainfall, and physiographic influences. Man's role, however, is by far the most important.

The present study grew from a recognition of the incongruous and anomalous conditions. Of especial interest is the cultural acceleration of sedimentation and the considerable spatial variation of its effects.

The area selected for investigation is the Oconee River Watershed upstream from Milledgeville, Georgia, an area of 2,891 square miles.[28] The Study Area, shown in Figure 1, lies entirely within the Piedmont Physiographic Region.

This thesis attempts a geographical analysis of the evolution of culturally accelerated sedimentation phenomena in the Study Area. The time span considered is from European settlement to the present. The first chapter attempts to reconstruct the stream morphology of the Study Area at the outset of European settlement with some indication as to what effects the initial clearing of forests had on streams. The second chapter then shows the rapid changes in stream morphology between _circa_ 1890 and 1940, the era of extensive row cropping and its aftereffects, and culminates in a map showing the distribution of sedimentation in the Study Area. In Chapter Three, the considerable similarities between the distribution of sedimentation and the distribution of erosion damage are emphasized and analyzed so that the distribution of sedimentation may be explained through the consideration of primarily erosional factors. Of these erosional factors, man's use of the land emerges as the primary factor. Chapter Four examines the changing land use since _circa_ 1940 and the changes in stream morphology which are presently occurring as a result of these recent land use changes.

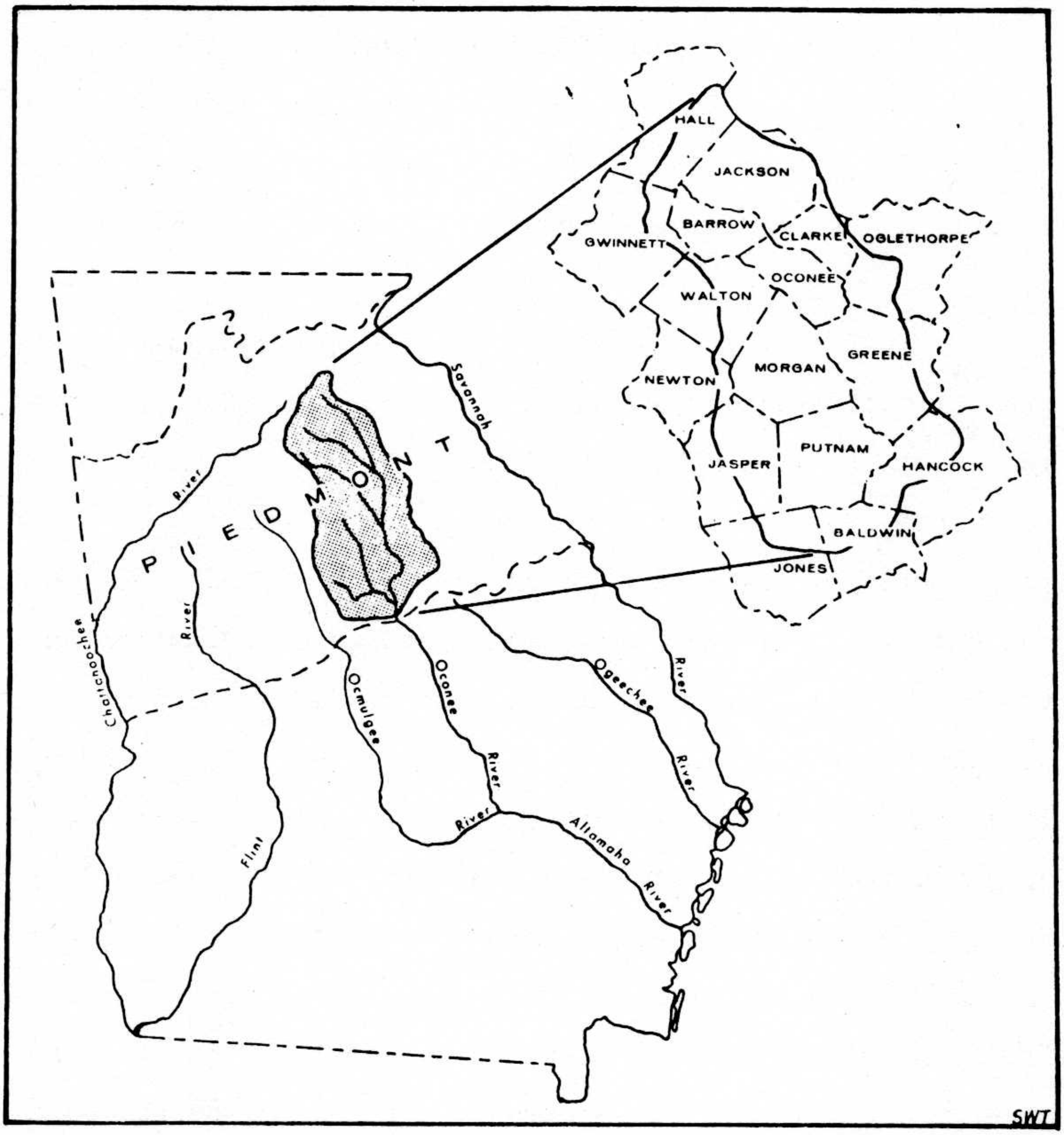


Figure 1. The Study Area.

NOTES

[1]For this study, the term "valley morphology" includes both stream and valley morphology. It also includes physical conditions along streams and valley floors, including soils, ground water level, and vegetation.

[2]"European" denotes the culture complex involved and may include peoples of diverse races.

[3]Jay A. Bonsteel, "Soils of the Eastern United States and Their Use," XXXIX, "Meadow," U. S. Bureau of Soils Circular No. 68, 1912, p. 14. See also Mark Baldwin and David D. Long, Soil Survey of Jackson County, Georgia, U. S. Department of Agriculture, Bureau of Soils, (Washington: 1915), p. 24.

[4]"Sedimentation" in this study includes all forms of deposition of water-borne solid materials. The sediment materials which are most significant to this study are coarse, sandy materials removed primarily from subsoils and transported by streams mainly as bedload. "Sedimentation" is often used during this study in a conceptual sense and includes all phenomena and effects of sedimentation. "Significant Sedimentation" indicates that enough sedimentation occurred to materially change stream morphology. "Culturally accelerated sedimentation" is sedimentation as a result of accelerated soil erosion caused by man's use of the land.

[5]Sir Charles Lyell, A Second Visit to the United States of North America, (New York: 1849), Vol. I, p. 256, Vol. II, pp. 28-31.

[6]U. S. Bureau of the Census, Tenth U. S. Census, 1880, Reports on Water Powers of the United States, p. 149. E. Merton Coulter, "Scull Shoals: An Extinct Georgia Manufacturing and Farming Community," in E. Merton Coulter, Georgia Waters, (Athens: 1956), pp. 101-102.

[7]Bonsteel, "Soils of the Eastern United States . . . ," pp. 13-14.

[8]S. W. McCallie and the U. S. Department of Agriculture, A Preliminary Report on Drainage Reclamation in Georgia, Geological Survey of Georgia, Bul. No. 25, (Atlanta: 1911).

[9]H. H. Barrows and J. V. Phillips, Agricultural Drainage in Georgia, Geological Survey of Georgia, Bulletin No. 32, (Atlanta: 1917).

[10]Ibid., pp. 11-12.

[11]U. S. Bureau of the Census, Fourteenth Census of the United States: 1920, Irrigation and Drainage, 424; Fifteenth Census of the United States: 1930, Drainage of Agricultural Lands, 87; Sixteenth Census of the United States: 1940, Drainage of Agricultural Land, 115; Seventeenth Census of the United States: 1950, Drainage of Agricultural Lands, IV, 22; Eighteenth Census of the United States: 1959, Drainage of Agricultural Lands, IV, 38.

[12]A check at the Jackson County, Georgia, Courthouse in March, 1969, revealed that the individual counties had kept no records of these drainage projects.

[13]Stafford C. Happ, "Sedimentation in South Carolina Piedmont Valleys," American Journal of Science, Vol. CCXLIII, No. 3, (March, 1945), p. 125.

[14]For extensive surveys of literature concerning culturally accelerated erosion and sedimentation, see the following references: Stafford C. Happ, Gordon Rittenhouse, and G. C. Dobson, "Some Principles of Accelerated Stream and Valley Sedimentation," U. S. Department of Agriculture Technical Bulletin No. 695, May, 1940, pp. 1-10 and 116-120. Luna B. Leopold, "Land Use and Sediment Yield," in William L. Thomas, Jr., (ed.) Man's Role in Changing the Face of the Earth, (Chicago: 1956), pp. 639-647.

[15]L. C. Gottschalk, "Effects of Soil Erosion on Navigation in Upper Chesapeake Bay," Geographical Review, Vol. XXXV, (1945), p. 223.

[16]Happ, et al, 1940, pp. 4-10.

[17]For especially valuable bibliographies, see Happ et al, pp. 116-120 and Leopold, pp. 646-647.

[18]Henry M. Eakin and associates, "Silting of Reservoirs," U. S. Department of Agriculture Technical Bulletin No. 524, (1936), p. 142.

[19]Happ, et al, 1940.

[20]Ibid., p. 115.

[21]Arthur N. Strahler, "The Nature of Induced Erosion and Aggradation," in William L. Thomas, Jr. (ed.) Man's Role in Changing the Face of the Earth, (Chicago: 1956), pp. 621-638.

[22] Ibid., p. 621.

[23] This statement is made after extensive bibliographic research. In recent years, U. S. Department of Agriculture Soil Surveys have been released for Clarke, Oconee, Morgan, Walton, and Gwinnett Counties. These studies do not, however, place emphasis on modern sediments.

[24] U. S. Department of Agriculture, Agricultural Research Service, "A Universal Equation for Predicting Rainfall-Erosion Losses--An Aid to Conservation Farming in Humid Areas," Agriculture Research Service Special Report 22-66, March, 1961.

[25] G. M. Brune, "Rates of Sediment Production in the Midwestern United States," U. S. Soil Conservation Service Technical Pamphlet No. 65, cited in Leopold, p. 642.

[26] Luna B. Leopold, "Land Use and Sediment Yield."

[27] Strahler, p. 623.

[28] U. S. Congress, House, Altamaha, Oconee, and Ocmulgee Rivers, Georgia, House Document No. 68, 74th Congress, 1st Session, 1935, p. 23.

CHAPTER ONE

THE VALLEY MORPHOLOGY PRIOR TO EUROPEAN SETTLEMENT

In order to ascertain the extent of change in valley morphology since European settlement as a result of culturally accelerated sedimentation, it is first necessary to reconstruct the valley morphology in the area as it existed before Europeans established permanent occupance. The principal sources of information available for such a reconstruction are the original plats of survey on file in the office of the Surveyor General of Georgia.[1] Supplementary information is obtained from the published accounts of knowledgeable travelers of the period.

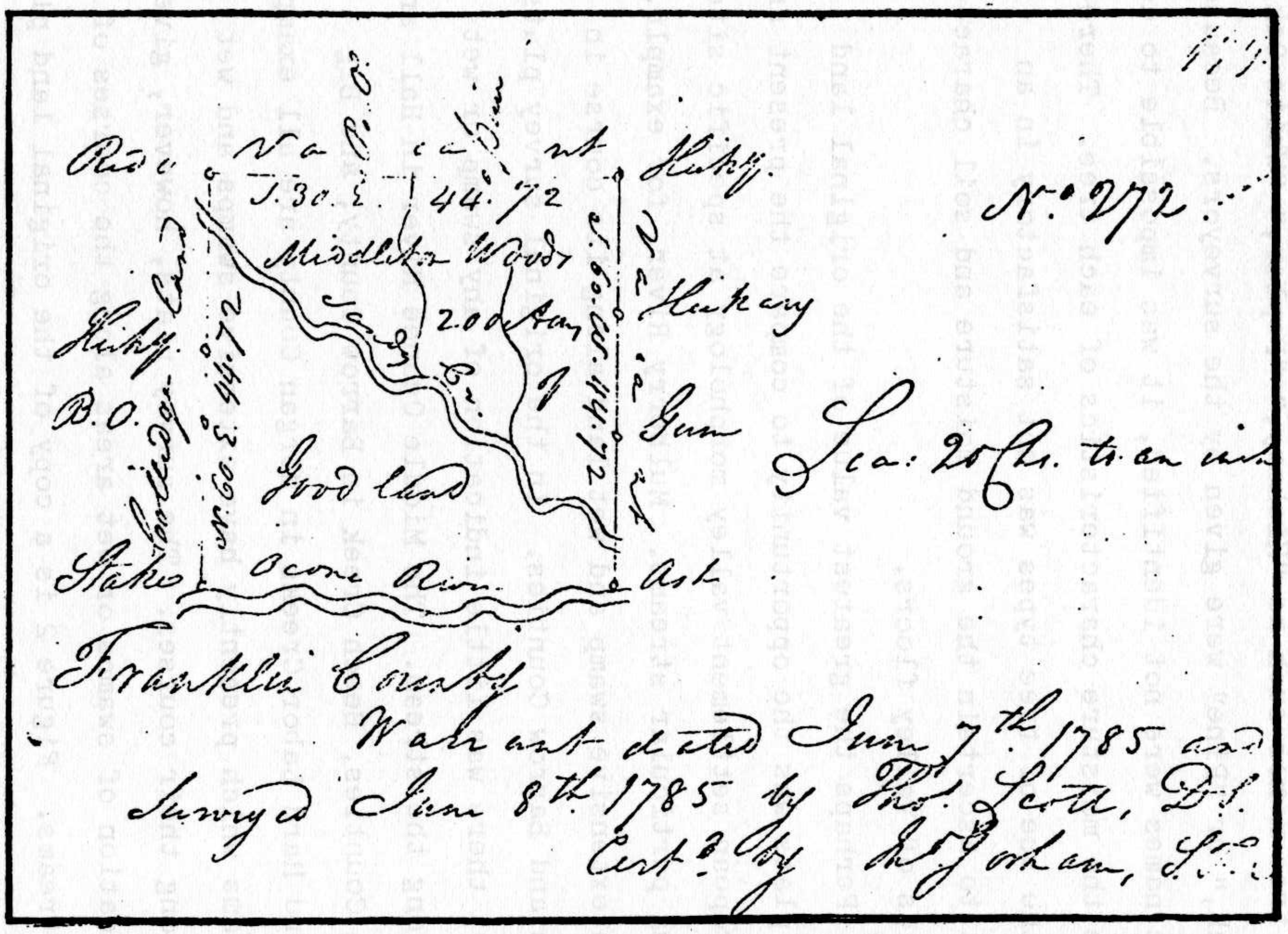
The original plats of survey are fairly accurate, large scale sketches of the pre-settlement landscape with certain landscape features emphasized. The original surveyors of the northern portion of the Study Area, for example, were instructed in part as follows: "In your field books, you are to note down . . . all large lakes, swamps, ponds, and other remarkable objects touched or crossed . . . ."[2] To insure that the surveyors did submit accurate and complete land plats, they were put under a bond of $10,000.[3] Thus, any stream valley swamps, wet land, or other land unsuitable for agriculture should have been noted. Later evidence examined in the course of this study appears to indicate that the original plats of survey are substantially accurate.

Presently, the preponderance of stream valley swamps and wet lands are found in the northern half of the Study Area. Consequently, nearly all of the several hundred survey plats of the northern half of the Study Area were inspected. Survey plats for the southwestern portion of the Study Area were selectively inspected; sites selected for inspection were those which are now in swamp or marsh. Of all the stream valleys inspected on the original survey plats, only a small percentage had any special notation denoting physical conditions along the valley floor. The most numerous of these notations were "cane brake," "cane swamp," "low ground," and "bottom." "Tillable cane swamp" was an occasional notation. Only one "swamp" notation was found in the Study Area. There was no indication on any plat of a lack of a definite stream channel. Interestingly, if not significantly, these special stream valley notations were usually along the larger streams while the valleys of smaller streams were usually not annotated. Presently, most swamp and wet land development is along the smaller headwater streams, suggesting that these headwater swamps have developed since the land was originally surveyed.

The survey plats gave no definition or description of "cane brake" or "cane swamp." In an attempt to determine the ground moisture and soil characteristics of such areas, samples were taken from the trees identified on survey plats as growing either in "cane brake" or "cane swamp." Only common tree names such as "Hickory," "Poplar," "White Oak," "Red Oak," or "Pine" were given by the surveyors. Because species names were not identified, it was impossible to determine the moisture characteristics of each tree. Therefore, the use of tree types was not satisfactory in an attempt to ascertain the ground moisture and soil characteristics of valley floors.

Perhaps the greatest value of the original land survey plats was the opportunity to compare the present and pre-European settlement valley morphology at specific sites or along particular streams. Mulberry River, for example, now has extensive swamp and wet land along its course in Jackson and Barrow Counties. In the original survey plats, however, there was little indication of any swamp or wet area along the stream. The Middle Oconee River in Hall and Jackson Counties, Beech Creek in Barrow County, and Big Sandy and Hard Labor Creeks in Morgan County are all examples of streams which presently have extensive swamps and wet land along their courses. The survey plats, however, give no indication of swamps or wet areas along the courses of these streams. Figure 2 is a copy of the original land plat survey of the confluence of Sandy Creek and the North Oconee River, dated 1785. This area, now in Clarke County, was noted as "good land" in 1785 but is now perennially

Figure 2. Original Land Survey Plat of the Confluence of Sandy Creek with the North Oconee River, Dated January 8, 1785.



Source: Headrights Plat Book "N", p. 149, Office of the Surveyor General, Georgia State Records and Archives, Atlanta, Georgia.

inundated and is part of a large wet area covering several hundred acres.

Bartram, the observant eighteenth century naturalist, often noted the existence of "cane brakes" and "cane swamps" in his travels across the Georgia Piedmont.[4] In a traverse across the extreme southern portion of the Study Area, for example, Bartram notes that he:

> . . . passed over a pleasant territory, presenting varying scenes of gentle swelling hills and levels affording sublime forests, contrasted by expansive illumined green fields, native meadows and cane brakes.[5]

Exactly what Bartram meant by "cane swamp" and "cane brake" is a bit uncertain. He noted that the "cane swamps" along the Oconee River were "incredibly fertile," probably indicating that these areas were suitable for agriculture.[6] Later, while camped on a tributary of the Flint River, he notes that:

> The adjacent low grounds and Cane Swamp afforded excellent food and range for our horses . . . . The territory lying upon this creek . . . present[s] every appearance of a delightful and fruitful region in some future day, it being a rich soil and exceedingly well situated for every branch of agriculture and grazing . . . .[7]

It appears that perhaps "cane swamp" or "cane brake" did not necessarily indicate a swamp in the presently accepted sense of wet, soggy land. Francis Harper, the naturalist who annotated the travels of Bartram, defines "cane swamp" as "damp areas grown with one or both species of <u>Arundinaria</u> [cane] . . . ."[8] He defines a "cane brake" or "cane meadow" as "a more or less dense and extensive growth of canes . . . ."[9] It thus appears that "cane brake" and "cane swamp" were at most only damp areas and did not indicate a swamp as presently conceived. Further evidence indicates that most of the bottom land in the Study Area was suitable for agriculture at the time of settlement. A Waynesboro, Georgia, physician, writing before 1806, described Piedmont bottom land in these terms:

> Most of the creeks and rivers have a margin of swamp of varied extent, which is often overflowed in wet seasons to the great injury of the planters. These swamps are very rich, and when cultivated produce very plentiful crops; but it is generally expected to lose one in every four or five, by the freshets. They [the swamps] are heavily timbered . . . .[10]

It thus appears that much of the bottom land was being cultivated from the time of initial European settlement. The importance of bottom land in nineteenth century Piedmont agriculture was noted by Bonsteel, a U. S. Department of Agriculture soil scientist, in 1912.[11] Baldwin and Long, also soil scientists, wrote in 1914 that bottom land, especially areas of Congaree silty clay loam, was the "chief farming area" in the early days of what is now Jackson and Barrow Counties.[12]

Another method of ascertaining the ground moisture and soil characteristics of the pre-settlement stream valleys is the analysis of soil types. The U. S. Department of Agriculture soil surveys completed in the Study Area from 1901-1929 indicated that nearly all bottom land was Congaree silty clay loam, Congaree fine sandy loam, or Meadow soil at the time of survey. Furthermore, much of the bottom lands classed as Meadow had been one of the Congaree soils before the deluge of modern sediment.[13] Therefore, much of the original bottom land soil was Congaree. This soil has an A and C horizon which means that the water table has been at least thirty to thirty-six inches below the surface for hundreds of years. Also, the fact that this Congaree soil was able to develop without mottling indicates that much of the Piedmont bottom land was relatively dry.

It is reasonably established, also, that the Oconee was clear before settlers cleared the forests. While traveling in the Piedmont, Bartram often noted the clarity of streams and the fact that the stream beds were rocky. He twice referred to the Oconee River as being "beautiful."[14] It is certainly difficult to perceive of the present Oconee River as being beautiful. The water is turbid, especially during times of high stream discharge, and the banks are often sandy or swampy. Overflows leave a coat of mud over the banks and streamside vegetation. The present condition of the river, however, is much improved from the era of extensive row cropping, thirty to sixty years ago. At that time, the turbidity was several times the present rate.[15] Regarding the turbidity of the Oconee, Sir Charles Lyell made the following observation in December of 1845:

> As our canoe was scudding through the clear waters of the Altamaha, Mr. Couper mentioned a fact which shows the effect of herbage, shrubs, and trees in protecting the soil from the wasting action of rain and torrents. Formerly, even during floods, the Altamaha was transparent, or only stained of a darker color by decayed vegetable matter, like

> some streams in Europe which flow out of peat mosses. So late as 1841, a resident here could distinguish on which of the two branches of the Altamaha, the Oconee or Ocmulgee, a freshet had occurred, for the lands in the upper country, drained by one of these (the Oconee) had already been partially cleared and cultivated, so that that tributary sent down a copious supply of red mud, while the other (the Ocmulgee) remained clear, though swollen. But no sooner had the Indians been driven out, and the woods of their old hunting ground begun to give way before the ax of the new settler, than the Ocmulgee also became turbid.[16]

Lyell also made further observations on accelerated erosion as the result of clearing the land. In January, 1846, he surveyed a gully near Milledgeville, Georgia. This gully, in the twenty years since the land had been cleared, had enlarged to 300 yards in length, 55 feet in depth, and 180 feet in width. Gullies were evidently frequent occurrences, even as early as 1846.[17] The importance of gullying to stream sedimentation will be considered later in this study.

Mention has been made of pre-European settlement Piedmont streams having rocky bottoms. In completing the extensive field research for this study as described in Chapter Two, the investigator found many sediment-filled streams which, according to sources consulted, had been flowing on bedrock only fifty to seventy-five years ago. The sample taken during field research indicated that a large portion of Study Area streams once flowed on bedrock.

In general, before European settlement, streams in the Study Area appear to have been clear, stream beds were rocky, stream channels were definite, and overflows were much less frequent than in the past fifty or sixty years. Bottom land along valley floors was reasonably dry and tillable, although there were some low, damp areas. It is possible that very infrequent wet places may have existed, but most bottom land along streams had been dry long enough for soil horizons to develop. This cultivable bottom was of great agricultural importance to the early settlers.

NOTES

[1]Located at the Office of the Surveyor General, Georgia State Records and Archives Building, Atlanta, Georgia. The original plats of survey are large-scale sketches of the pre-European settlement landscape. There are two types of surveys within the Study Area, the headrights survey and the state rectilinear survey. Present Study Area counties included in the headrights surveys are Hancock, Greene, Oglethorpe, Clarke, Oconee, Barrow, Jackson, Hall, and Gwinnett. The approximately 60,000 headrights survey plats are chronologically arranged in forty-nine volumes. These plats are indexed by the original owners' names but are not areally indexed. Thus, a search for a specific plat, known only by its location, entails searching through all forty-nine headrights volumes. Included in the state rectilinear survey portion of the Study Area are the present counties of Baldwin, Putnam, Jones, Jasper, Morgan, and Walton. The state rectilinear survey portion of the Study Area is areally indexed so that any part of the present landscape may be compared with the original survey plats. All survey plats in the plat volumes are copies of the originals and are subject to recopying errors. In most cases, the original plat is on file and may be inspected.

[2]Manuscript copy of instructions given to surveyors of the original Franklin County, Georgia, circa 1784, Office of the Surveyor General, Georgia State Records and Archives Building, Atlanta, Georgia.

[3]Interview with Mrs. Pat Bryant, Deputy Surveyor General of Georgia, Office of the Surveyor General, Georgia State Records and Archives Building, Atlanta, Georgia, March 20, 1969.

[4]Francis Harper (ed.), The Travels of William Bartram: Naturalist's Edition, (New Haven: 1958).

[5]Ibid., p. 241.

[6]Ibid., p. 25.

[7]Ibid., p. 242.

[8]Ibid., p. 463.

[9] *Ibid.*

[10] Dr. Joshua White, "Cursory Observations on the Soil Climate, and Diseases of the State of Georgia," New York Medical Repository, Vol. IX (February, March, and April, 1806), p. 351.

[11] Jay A. Bonsteel, "Soils of the Eastern United States and Their Use," XXXIX, "Meadow," U. S. Bureau of Soils Circular No. 68, 1912, p. 14.

[12] Mark Baldwin and David D. Long, Soil Survey of Jackson County, Georgia, U. S. Department of Agriculture, Bureau of Soils, (Washington: 1915) pp. 25-26.

[13] *Ibid.*

[14] Harper, pp. 26, 290.

[15] See the discussion concerning the reduction of turbidity in the Oconee River during the past thirty years in Chapter Four of this thesis. Many residents of the Study Area, interviewed in the course of this study, have stated that the turbidity of streams during the era of extensive clean-cultivated crops was much greater than presently.

[16] Sir Charles Lyell, A Second Visit to the United States of North America, (New York: 1849), Vol. I, p. 256.

[17] Lyell, Vol. II, pp. 28-31.

CHAPTER TWO

CHANGES IN VALLEY MORPHOLOGY DURING THE ERA OF CULTURALLY ACCELERATED SEDIMENTATION

circa 1890-1940

This chapter considers the changes in valley morphology which took place during the era of culturally accelerated sedimentation. The era of accelerated sedimentation was approximately concurrent with an extended period of erosive land use characterized by steadily decreasing forest land, a sharply increasing proportion of land planted to row crops, and a general lack of soil conservation measures. The relation of this erodable land to sedimentation will be considered in Chapter Three.

Existing documentary sources concerning recent valley morphology in the Study Area have been briefly discussed in the Introduction to this thesis. These studies, although usually accurate and informative, were not sufficiently complete to allow the construction of a total picture of the changes in stream morphology which took place during the era of culturally accelerated sedimentation, *circa* 1890-1940. Consequently, a program of extensive field research was undertaken to complement existing information. The field research included the inspection of several hundred points along streams throughout the Study Area and required approximately eighty days of field investigation. This research culminated in a documented report of twenty-two Investigation Sites, parts of which are included in this chapter. The evolution of valley morphology was traced at each site, beginning with pre-settlement conditions when possible. The selection of the Investigation Sites, shown on Figure 3, was based on four criteria. They are:

1. Significant sedimentation had to be present.
2. Some reference point or points upon which measurements through time could be made were required. These references or indices usually took the form of man-made objects such as dams or bridges. Older bridges were especially useful when plans were available. Natural indices such as bedrock, shoals, and other rocks were also helpful.
3. Other information concerning the site such as published material, surveys, and knowledgeable local residents was required.
4. It was desired that the total sample include all significant processes and phenomena of accelerated sedimentation.

Criterion One was fairly ubiquitous in the northern portion of the Study Area; criteria Two and Three were were more difficult to locate. The sites selected for investigation are those which best meet the specified criteria.

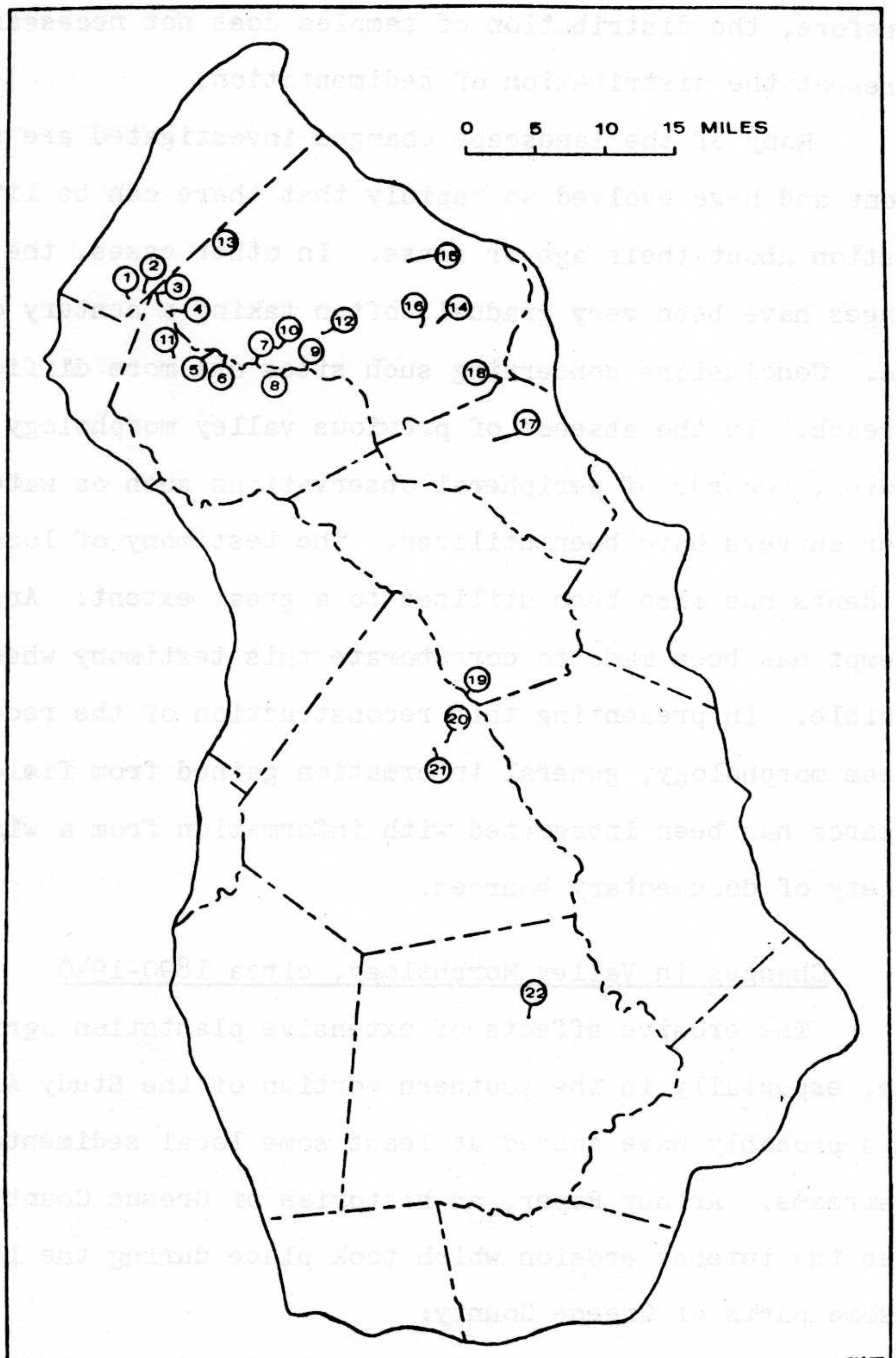


Figure 3. The Study Area Showing the Location of Investigation Sites.

Therefore, the distribution of samples does not necessarily represent the distribution of sedimentation.

Many of the landscape changes investigated are so recent and have evolved so rapidly that there can be little question about their age or cause. In other cases, the changes have been very gradual, often taking a century or more. Conclusions concerning such sites are more difficult to reach. In the absence of previous valley morphology studies, records of peripheral observations such as water power surveys have been utilized. The testimony of local residents has also been utilized to a great extent. An attempt has been made to corroborate this testimony when possible. In presenting this reconstruction of the recent stream morphology, general information gained from field research has been integrated with information from a wide variety of documentary sources.

Changes in Valley Morphology, circa 1890-1940

The erosive effects of extensive plantation agriculture, especially in the southern portion of the Study Area, would probably have caused at least some local sedimentation of streams. Arthur Raper, an historian of Greene County, notes the intense erosion which took place during the 1850's in some parts of Greene County:

> . . . The wasting soil from the fields continued to fill up the spring branches, pour into the creeks and then into the Oconee and the Ogeechee. The fish were failing in the muddy waters. Floods and droughts were worse as forests were cleared and springs dried up.[1]

Such intense erosion apparently resulted in limited stream sedimentation. Raper notes that in the 1850's some Greene County farmers had "commenced to straighten creeks" and "drain swamps."[2] Although some accelerated sedimentation had probably taken place elsewhere in the Study Area, no other reference to sedimentation before the 1880's has been found. A water power survey of 1883 mentioned incidentally that the Appalachee River was filling with sand.[3] E. M. Coulter, University of Georgia Professor of History Emeritus, noted the sedimentation of Rose Creek in Oconee County in the mid-1880's.[4] Significant sedimentation, however, did not become widespread until the beginning of the twentieth century.

The first step in the sedimentation process, the filling of stream channels with sandy sediment, usually led to other even more detrimental effects. A common result of filled channels is for much of the stream discharge to flow through the sand beneath the surface of the channel. Reduced surface discharge in turn decreased the stream's sediment load capacity and further increased the deposition of sediment. Several streams in the Study Area have had their surface discharge noticeably reduced in the past fifty to seventy-five years. The channel cross section of the Mulberry River between Barrow and Jackson Counties in the vicinity of the Georgia State Highway 53 Bridge (Investigation Site 6), for example, has been greatly reduced by sedimentation in the past fifty to sixty years.[5] The real significance of subsurface flow was felt during the dry spells of summer and autumn. Sandy Creek is a sediment-filled stream with a drainage area of ninety-nine square miles in Clarke, Jackson, and Madison Counties. This stream has been observed when there was no surface discharge at the mouth.[6]

In some places, stream channels completely filled or were blocked with debris so that even the ordinary stream flow spread over the flood plain in shallow distributary channels. Infrequently, a distributary channel was scoured out enough so that it became a new main channel for the stream. A more significant result of channel filling was the increased frequency and magnitude of overbank flooding which often tended to scour the extensive clean-cultivated areas of bottom land. Much of the original fertile alluvial soil was thus removed and replaced by the comparatively infertile modern sediment.[7] The coarser sediment had varying degrees of fertility, but was often granitic sand of little agricultural value. In addition to soil damage, growing crops were often buried or partially buried during overflows.

Note has been made of the early U. S. Department of Agriculture Soil Surveys and the use of the classification "meadow" to denote the less fertile modern sediment. A 1914 soil survey of Jackson County, Georgia, recognized both the destructiveness and the origin of modern sediment when it stated that Meadow soil:

> . . . has been deposited since the upland soils have been cleared . . . . Some land which is now classed as meadow . . . was within comparatively recent years productive bottom land of a fine sandy loam or silty clay loam texture. Today, these areas are practically worthless.[8]

Piedmont soil surveys of the 1900-1925 period all indicated considerable portions of the valley floor soils classified as Meadow. Thus, much of the originally rich bottom land which had been important to agriculture was diminished in value.

Much more critical to agriculture than the deposition of Meadow soil was the creation of wet land, a process which is also preceded by channel filling. A Georgia agricultural drainage survey of 1917 gave a well-written description of the transformation of stream valleys to perennial wet land and swamp. The surveyor noted:

> As it [the water] leaves the channel and overflows the banks a marked reduction in velocity takes place and a large part of the sediment, especially the heavier and coarser material, is deposited at once on and near the banks. As the flood water extends back over the bottoms the finer and lighter material is carried with it and finally deposited where the water has little or no velocity. Since the bulk of the suspended matter is deposited near the point of overflow, it is apparent that this land will be built up more rapidly than will that lying further back from the channel. In course of time this building up progresses to such an extent that the land adjoining the channel is appreciably higher than the more remote land, and much of the water that overflows this barrier can not return by the same route and either must remain ponded or flow along the bottoms until it again can reach the channel through a ditch or branch stream.[9]

Thus, the creation of natural levees allowed overflow water to remain temporarily impounded on the valley floor.

In many places, the stream bed and natural levees were aggraded until the stream was at a higher level than the valley floor, thus permanently inundating valley floors. The distribution of wet and overflow land in the Study Area _circa_ 1919 is shown in Figure 4. This map shows the proportion of land which was too wet to cultivate or was overflowed so often as to be worthless for agriculture, conditions which, on the Piedmont, were caused by sedimentation. Note that the higher proportion tends to the north of the Study Area. The extreme southern counties have a higher proportion because part of their area lies inside the Coastal Plain, an area of more extensive wet land.

The relatively large amount of alluvial land lost to cultivation because of sedimentation constituted a grave economic problem to farmers who had depended heavily on the fertility and dependable moisture of these bottom lands. Bottom lands had most often been used for subsistence crops, especially corn, and for pasture. Because the bottom lands were of such economic import, land owners often formed drainage associations so that the newly formed wet lands might be reclaimed. These projects, financed by the landowners themselves, attempted to drain the wet areas by straightening and deepening (ditching) the stream channel. Valley floors could then be drained by ditching through the natural levees. These expensive drainage endeavors were largely unsuccessful because erosion, the source of the sediment, was undiminished and more importantly, because the base level of the streams

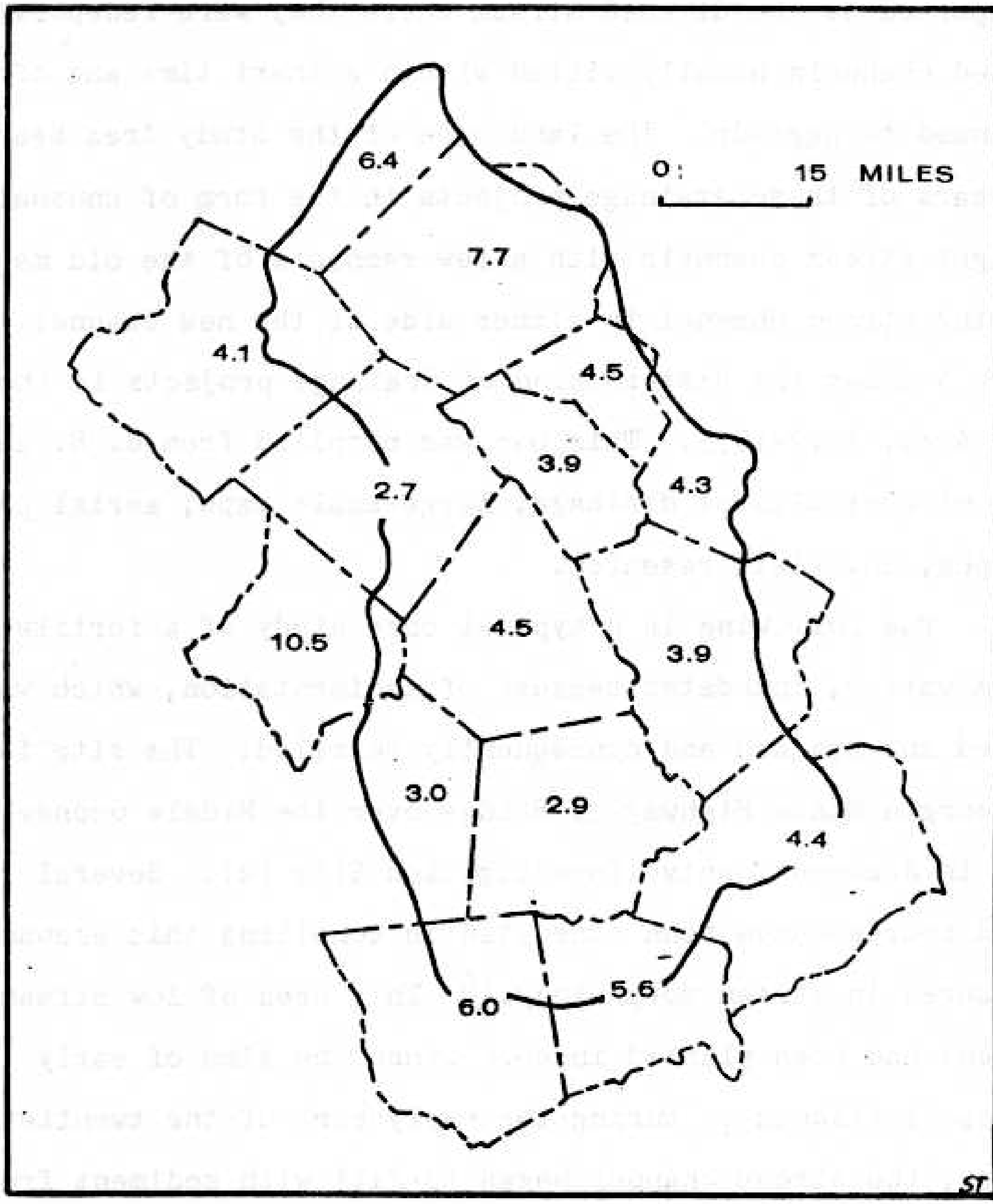


Figure 4. The Distribution of Wet and Overflow Land in the Study Area, circa 1915. Values shown are percentages of area in wet and overflow land. Source: H. H. Barrows and J. V. Phillips, Agricultural Drainage in Georgia, Geological Survey of Georgia, Bulletin No. 32, (Atlanta: Byrd Printing Company, 1917), pp. 48-108.

was lowered as a result of the ditching, thus causing sediment deposits in tributary streams to be reentrained and transported to the ditched stream where they were redeposited. Ditched channels usually filled within a short time and often continued to aggrade. The landscape of the Study Area bears the scars of these drainage projects in the form of unusually straight stream channels with a few remnants of the old meandering stream channel to either side of the new channel. Figure 5 shows the distribution of drainage projects in the Study Area, 1912-1955. This map was compiled from U. S. censuses of agricultural drainage, large-scale maps, aerial photographs, and field research.

The following is a typical case study of a fertile stream valley, inundated because of sedimentation, which was ditched and drained and consequently refilled. The site is the Georgia State Highway 11 Bridge over the Middle Oconee River in Jackson County (Investigation Site 12). Several varied sources have been consulted in compiling this account of changes in stream morphology.[10] This area of low stream gradient had been planted in corn since the time of early European settlement. During the early part of the twentieth century, the stream channel began to fill with sediment from upstream row crop erosion. A milldam, built before 1880 slightly downstream, raised the stream base level, causing upstream sedimentation rates to be greater than otherwise. As a consequence of sedimentation, the valley floor became too wet to cultivate and the river began to flood more often.

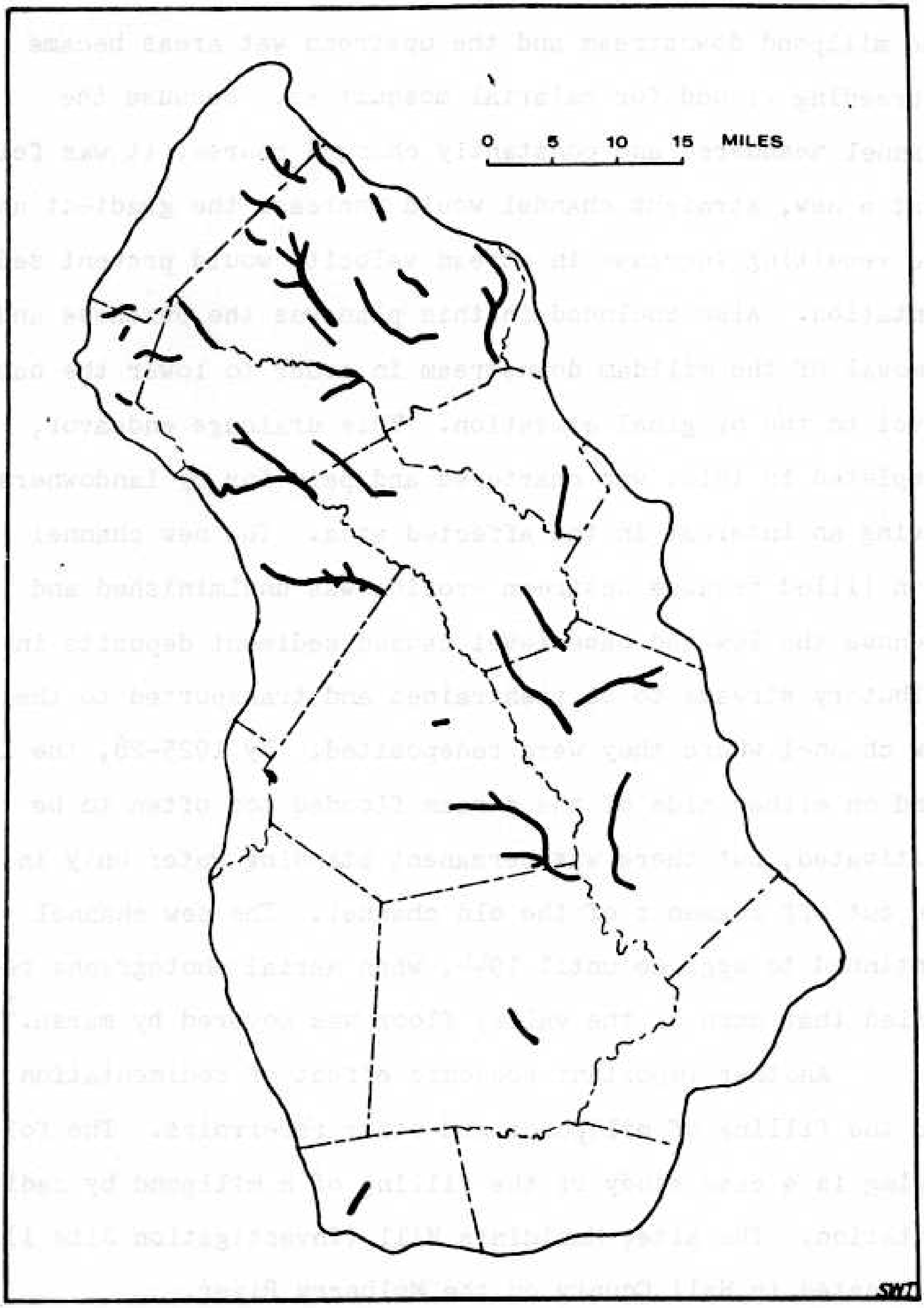


Figure 5. Drainage projects in the Study Area, 1912-1955.

The millpond downstream and the upstream wet areas became a breeding ground for malarial mosquitoes. Because the channel meandered and constantly changed course, it was felt that a new, straight channel would increase the gradient and the resulting increase in stream velocity would prevent sedimentation. Also included in this plan was the purchase and removal of the milldam downstream in order to lower the base level to the original elevation. This drainage endeavor, completed in 1918, was chartered and paid for by landowners having an interest in the affected area. The new channel soon filled because upstream erosion was undiminished and because the lowered base level caused sediment deposits in tributary streams to be reentrained and transported to the new channel where they were redeposited. By 1925-28, the low land on either side of the stream flooded too often to be cultivated, but there was permanent standing water only in the cut off segments of the old channel. The new channel continued to aggrade until 1944, when aerial photographs revealed that much of the valley floor was covered by marsh.[11]

Another important economic effect of sedimentation was the filling of millponds and other reservoirs. The following is a case study of the filling of a millpond by sedimentation. The site, Mauldin's Mill (Investigation Site 1), is located in Hall County on the Mulberry River.

The dam, as shown in Figure 6, was built on bedrock in about the year 1865 and was twelve feet high.[12] According to a deed, the dam was only nine feet high by 1896.[13] This would indicate three feet of filling below the dam which, in turn, indicates that the millpond had completely filled by that date. By 1906, there was so little head available (caused by filling of the channel downstream from the dam) that the turbines were no longer efficient and the mill was abandoned. A witness who saw the dam immediately after the mill was abandoned stated that there was only three feet of fall.[14] At that time, the banks were two and one-half feet higher than the top of the dam and were essentially in their natural condition. By 1925-30, as shown in Figure 6, the stream bed was approximately four feet above the top of the dam.

Many mill owners and operators, such as the Mauldin brothers who owned and operated Mauldin's Mill, were simply unable to cope with the tremendous amount of sediment and abandoned their mills. Other mill owners, in areas of less sedimentation or in more favorable locations, were able to continue operations for several years by continually draining their millponds. Sedimentation imposed an additional hardship on many mills which were already economically marginal, and they consequently had to cease operation. Referring to the demise of mills because of sedimentation, Eakin, an authority on the sedimentation of reservoirs, noted in 1936:

> Altogether, these smaller plants generate a really important aggregate power. Their intimate distribution and service among the rural communities of the Southern States for grist mill and other local uses, makes their gradual deterioration particularly grievous to a large proportion of the population.[15]

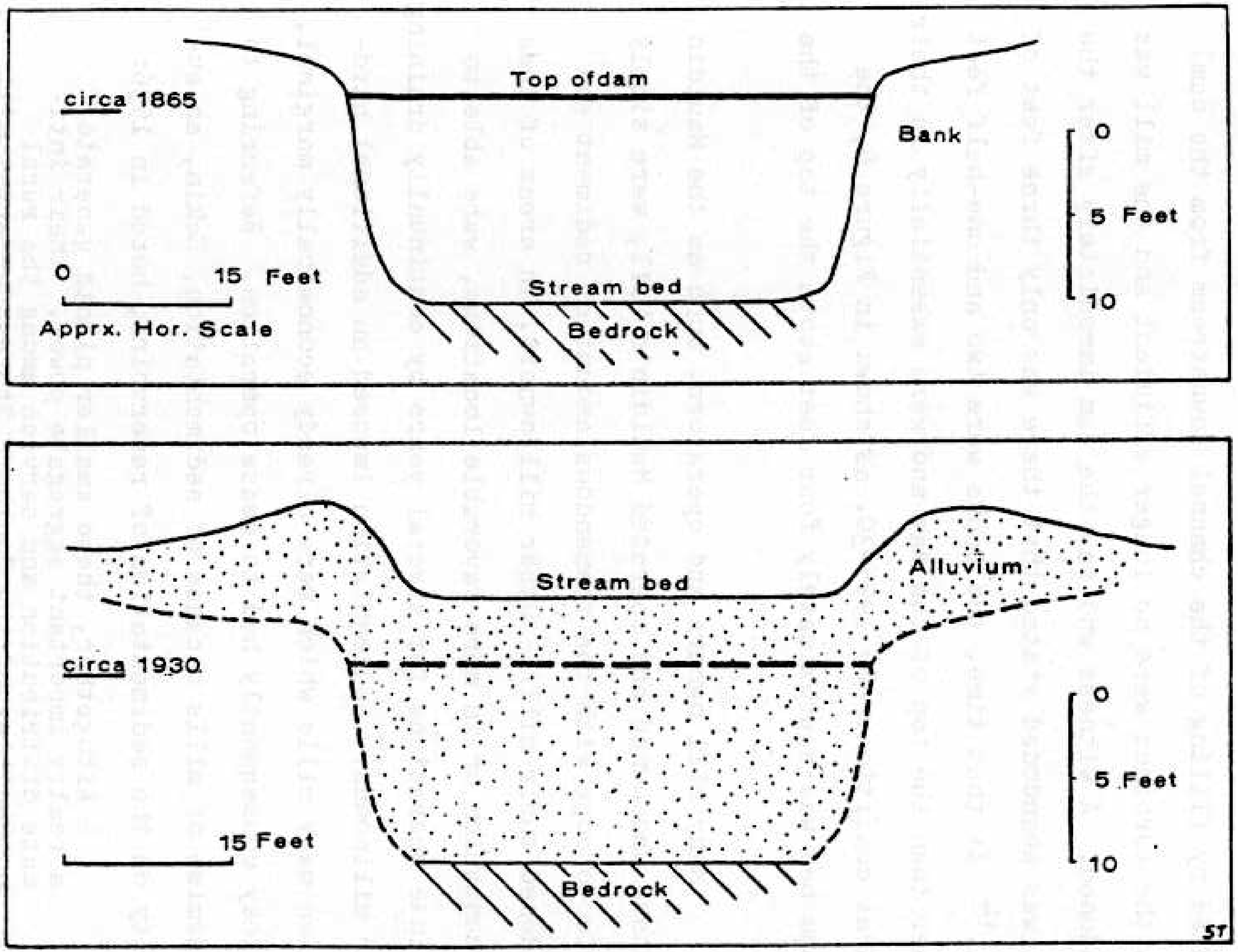


Figure 6. Mauldin Millsite, Investigation Site 1, Transverse Stream Profiles at Dam.

Figure 7 shows the distribution of reservoirs, mostly millponds, in the Study Area, circa 1900. Figure 8 indicates the mills whose abandonment was known to be either caused by or greatly influenced by sedimentation.

A less frequent result of channel filling and raised stream level was the diminishment of effective area of opening under highway bridges. Five bridges in the Study Area, all in the Mulberry River Watershed, were either covered by sediment or were overflowed too frequently to be of use. These bridges were usually removed or, when traffic demanded, the bridge was rebuilt at a higher level. Figure 9 shows the amount of aggradation since 1934 at the Georgia State Highway 53 Bridge over the Mulberry River, Investigation Site 6. The area of opening under this bridge has been reduced to a fraction of its 1934 size. The amount of aggradation before 1934 has not been ascertained, but it is thought to have been considerable inasmuch as the piers of the removed pre-1934 bridge are now covered with sediment. Although the bridge is in everyday use, there are several overflows each year, some serious enough to halt traffic. The Mulberry River at this site is still aggrading as a result of sediment migration, a current process which is discussed in Chapter Four. As may be ascertained from Figure 9, five additional feet of aggradation will render this bridge unusable at normal stream flow.

The Distribution of Sedimentation in the Study Area

This chapter has thus far considered the different types of changes in stream morphology which were effected by

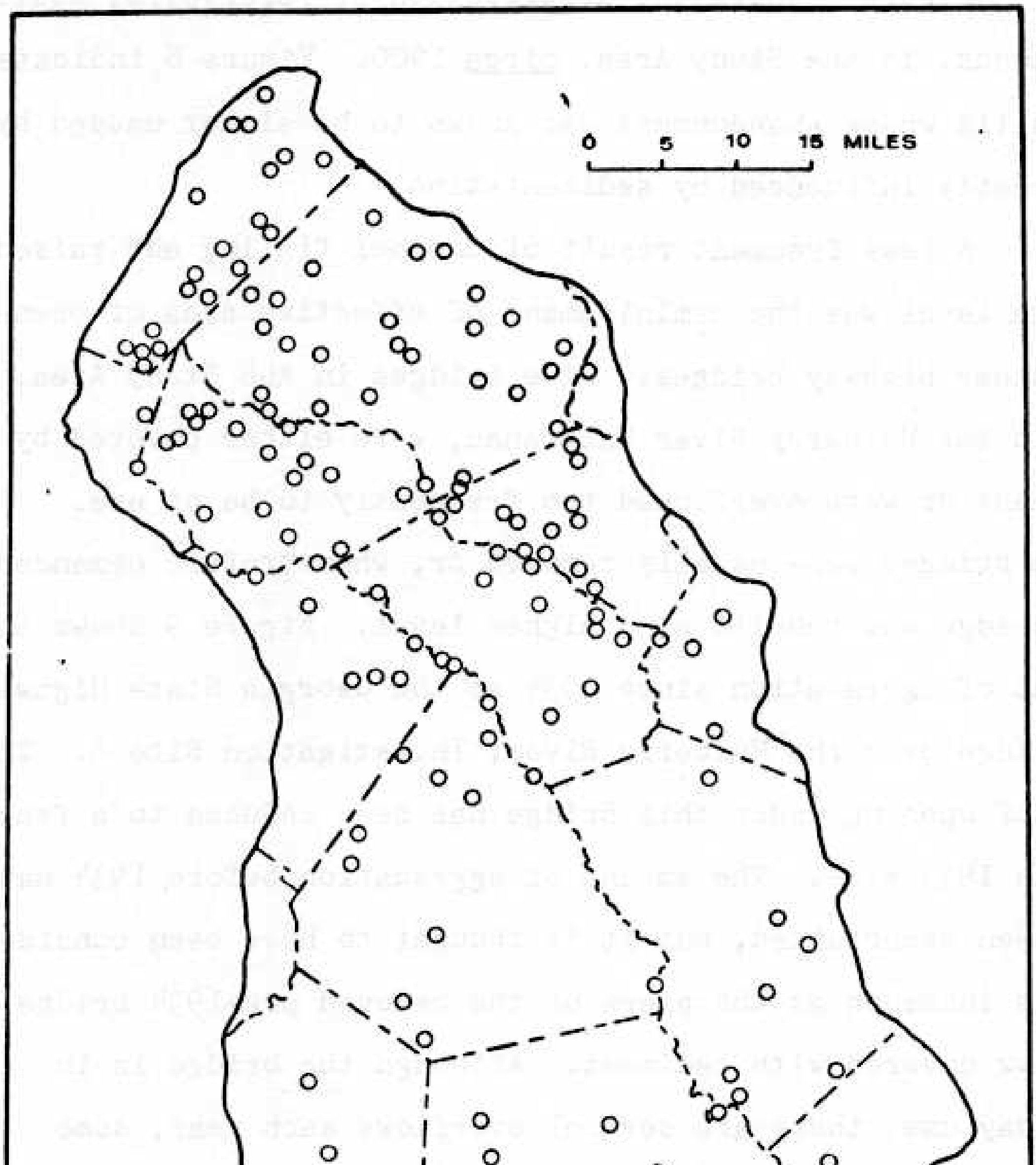


Figure 7. Millponds and Water-Power Reservoirs in the Study Area, circa 1900.

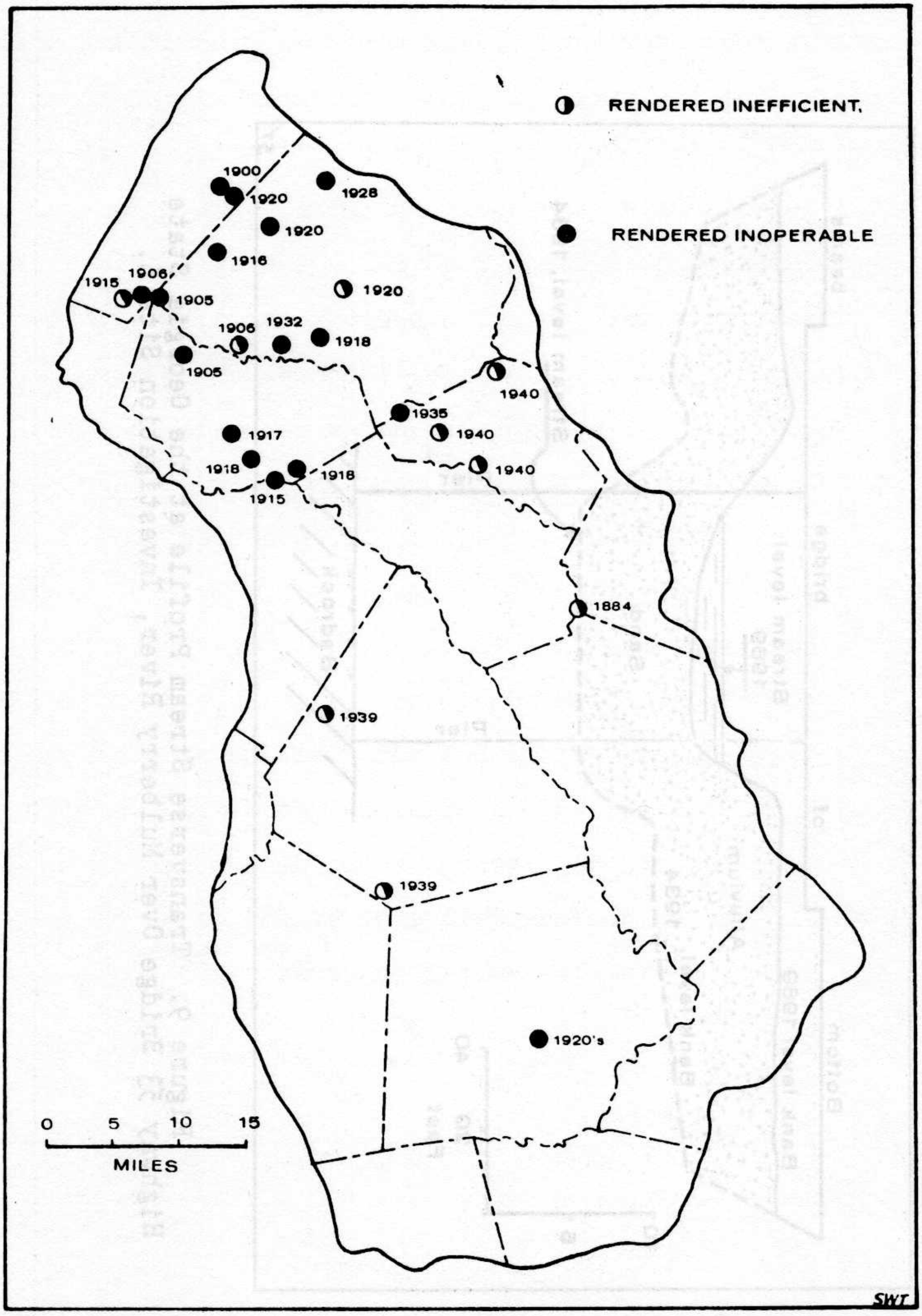


Figure 8. Mills and Other Water-Powered Installations Rendered Inoperable or Inefficient by Sedimentation. Date operation closed is indicated.

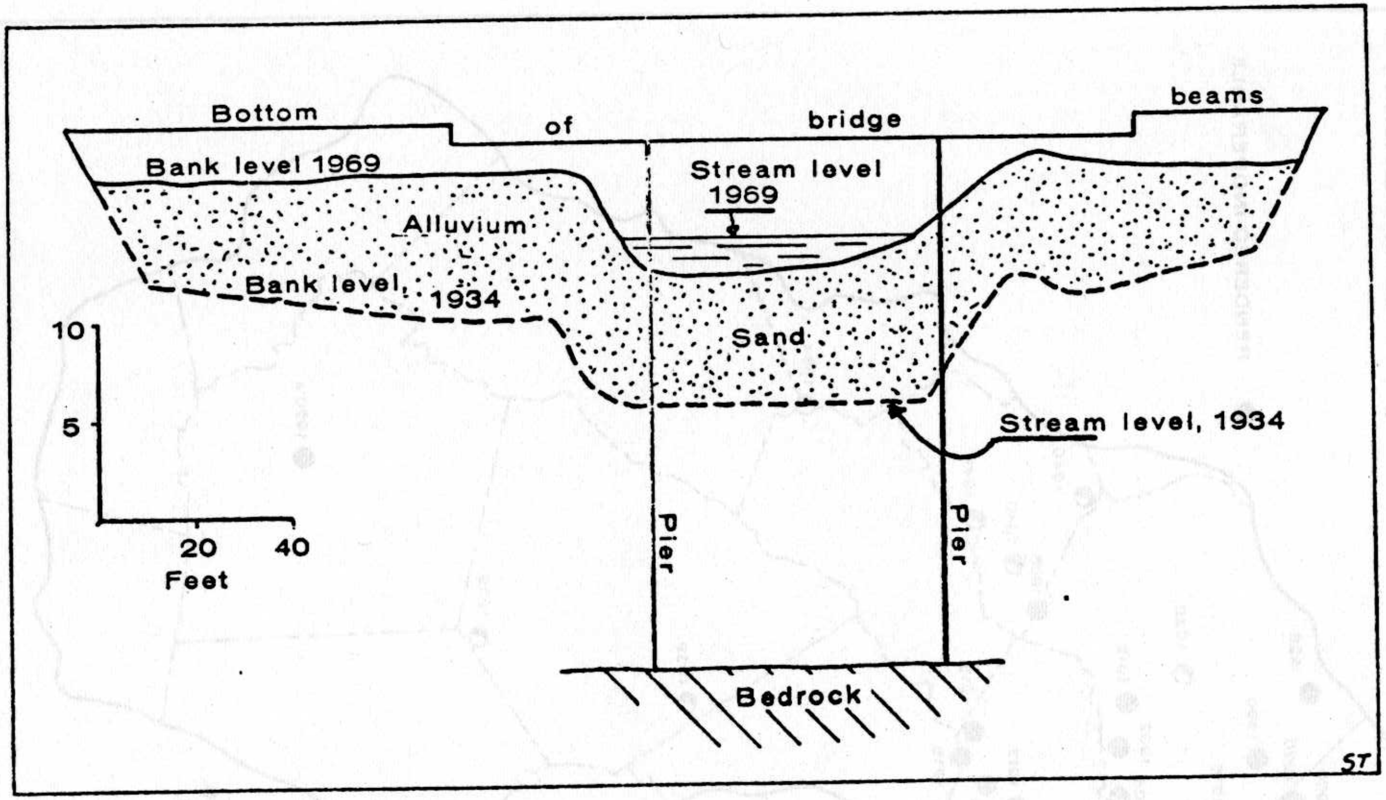


Figure 9. Transverse Stream Profile at the Georgia State Highway 53 Bridge Over Mulberry River, Investigation Site 6.

sedimentation. Although accelerated sedimentation was ubiquitous throughout the Study Area, there was great spatial variation in its magnitude. By compiling all the information available including field research, soil surveys, topographic maps, aerial photographs and interviews with knowledgeable individuals, Figure 10, The Distribution of Sedimentation in the Study Area, was compiled. The map was constructed by first noting the degree of sedimentation along each stream in the Study Area for which information was available. Areas homogeneous in sedimentation characteristics were then joined to form the sedimentation categories shown in Figure 10. Note the primary concentration of Type 1 sedimentation in the northern portion of the Study Area and a secondary concentration in the central portion. Type 2 sedimentation is widespread both in the north and in the west. Type 3 is predominant in the south, while Type 4 is found only in the south, primarily in Hancock County. An attempt is made in Chapter Three to relate this distribution to various causative factors of erosion and sedimentation.

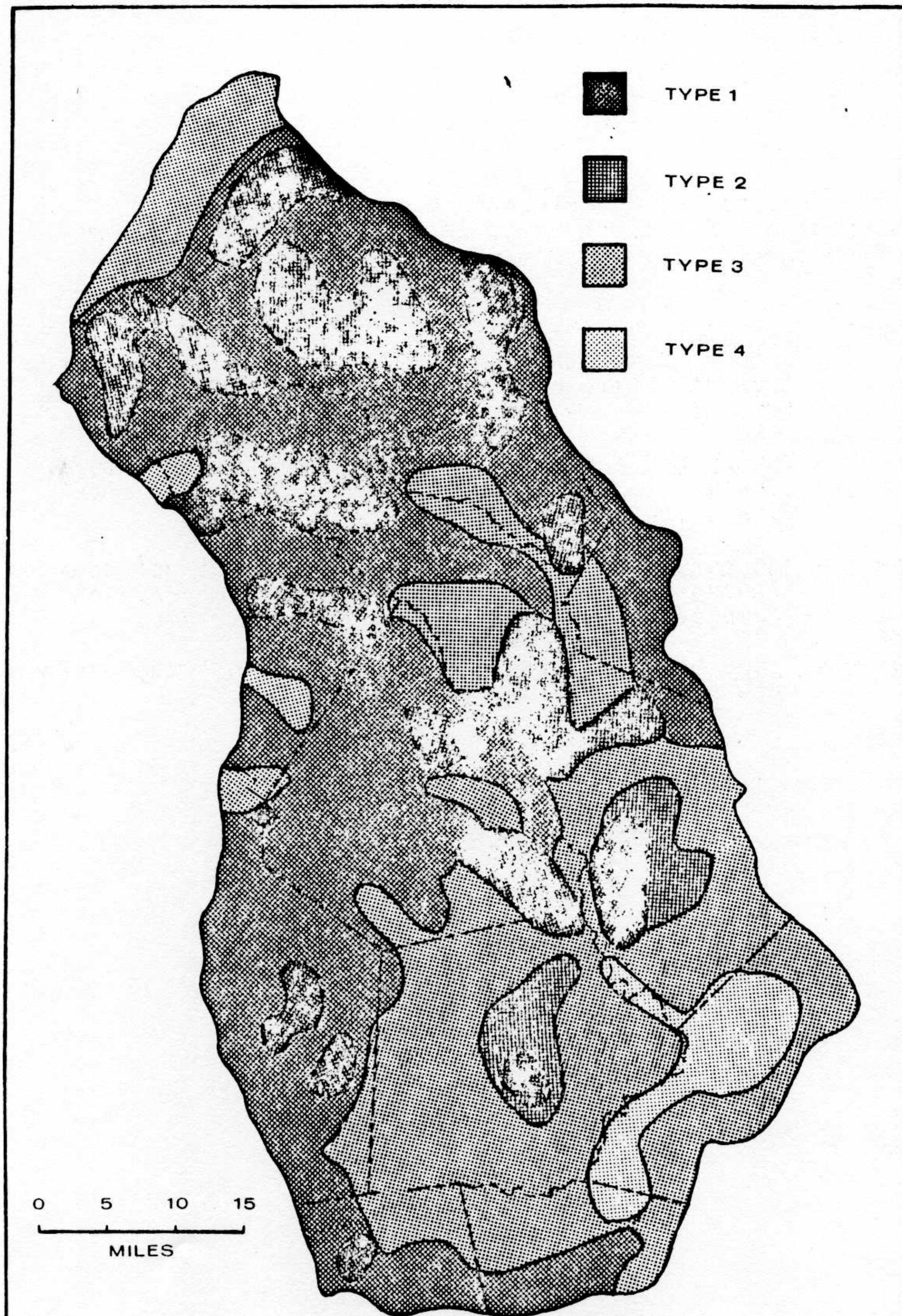
Figure 10. Generalized Composite Map of the Distribution of Sedimentation in the Study Area at Time of Greatest Effect of Sedimentation.

Type 1 - Very Severe Sedimentation. Filled stream channels, extensive overbank deposition, extensive wet areas, including perennial ponds and lakes, formed along streams.

Type 2 - Severe Sedimentation. Filled stream channels, extensive overbank deposition, frequent damp and marshy areas along streams.

Type 3 - Moderate Sedimentation. Extensive, but not continuous channel filling and overbank deposition, occasional wet or damp areas along streams.

Type 4 - Minor Sedimentation. Scattered channel and overbank deposition, insignificant wet areas.


TYPE 1
TYPE 2
TYPE 3
TYPE 4
0 5 10 15
MILES
SWT

NOTES

[1]Arthur F. Raper, Tenants of the Almighty, (New York: 1943), p. 55.

[2]Ibid., p. 54.

[3]U. S. Bureau of the Census, Tenth U. S. Census, 1880, Reports on Water Power of the United States, p. 149.

[4]E. Merton Coulter, "Scull Shoals: An Extinct Georgia Manufacturing and Farming Community," in E. Merton Coulter, Georgia Waters, (Athens: 1965), pp. 101-102.

[5]Interview with Mrs. Alec Hill and Mrs. Allie Stewart, Jackson County, Georgia, March 23, 1969.

L. L. Hidinger, a U. S. Department of Agriculture drainage engineer, states that this section of the Mulberry River was in 1909 "about 50 or 60 feet wide and eight to ten feet deep." (L. L. Hidinger, "The Improvement of Mulberry River, Jackson County," in S. W. McCallie and the U. S. Department of Agriculture, A Preliminary Report on Drainage Reclamation in Georgia, Geological Survey of Georgia, Bul. No. 25 (Atlanta: 1911), p. 93.) The present channel from the Georgia State Highway Bridge 124 to the Highway 53 Bridge is presently fifty to sixty feet wide and two to three feet deep. The phenomenon of reduced surface discharge as associated with sand-filled stream channels was mentioned by many other interview sources throughout the Study Area.

[6]Interview with Mr. Jack Beacham, retired city engineer of Athens, Georgia, June, 1969.

[7]Stafford C. Happ, "Sedimentation in South Carolina Piedmont Valleys," American Journal of Science, Vol. CCXLIII, (March, 1945), pp. 116-117. See also by the same author, Some Principles of Accelerated Stream and Valley Sedimentation, U. S. Department of Agriculture Technical Bulletin No. 695, (Washington: 1940), p. 72.

[8]Mark Baldwin and David D. Long, Soil Survey of Jackson County, Georgia, U. S. Department of Agriculture, Bureau of Soils, (Washington: 1915), pp. 25-26.

[9]H. H. Barrows and J. V. Phillips, Agriculture Drainage in Georgia, Georgia Geological Survey Bulletin No. 32, (Atlanta: 1917), pp. 12-13.

[10]Most of the account was compiled from interviews with the following Jackson County citizens in February and March, 1969: Mr. Ed Kelley, Mr. Ed Davis, Mrs. A. D. Mize, and Mr. C. T. Potter. The following documentation was used to supplement their testimony:

A search through the original Headright Grant plats at the Office of the Surveyor General, Georgia State Archives and Records, Atlanta, Georgia, did not result in finding a specific plat of this site, but among the many plats along the Middle Oconee River, not a single one carried the notation "wet" or "swampy." Many areas along the river were, however, marked as "lowland" or "cane brake." Many of the trees (dogwood, post oak, pines) noted in these low areas were not types which normally grow in wet areas.

A Jackson County, Georgia, warranty deed to this property, dated August 22, 1904, and giving a complete description of the property, was examined by the investigator. Along with the deed was a map of the property (scale: 1 inch = 10 chains) dated April 4, 1888. Neither the deed nor the map made mention of any wet or swampy areas on the property.

The 1891 USGS Topographic Sheet, Gainesville, Georgia, (Scale: 1:125,000) does not indicate any bog, swamp, marsh, or standing water along this stretch of river nor along any stream.

The 1914 Jackson County Soil Survey classified this area as Congaree silty clay loam which has already been described in this chapter.

[11]U. S. Department of Agriculture Aerial Photography, ATN (Jackson County, Georgia) -2C-43 and 44, April 5, 1944. "Marsh" here indicates an inundated valley floor covered by low, thick vegetation.

[12]Most of the information for this Investigation Site was supplied by Mr. G. N. Sloan, Hall County, Georgia, January, 1969.

[13]Deed belonging to Mr. G. N. Sloan, Hall County, Georgia.

[14]Interview with Mr. Milt Tanner, Hall County, Georgia, November, 1968.

[15]Henry M. Eakin, Silting of Reservoirs, U. S. Department of Agriculture Technical Bulletin No. 524, (Washington: 1936), p. 53.

CHAPTER THREE

THE ERA OF EXTENSIVE ROW CROPS: 1890-1940

After a consideration of the chronology and distribution of accelerated sedimentation, one should inquire into the causative factors which brought about the rapid acceleration of sedimentation and the marked spatial variation in the sedimentation phenomena. The answer to both questions is found primarily in accelerated erosion caused by man's use, or misuse, of the land in context of a combination of several natural factors.

This chapter will first note the close relationship between the distribution of sedimentation and the distribution of erosion. Attention will then be turned to the consideration of several major erosional factors in the Study Area, including man's role, in order to ascertain which erosional factors were most responsible for the distribution of sedimentation. The chapter's second portion will examine several factors which, once the sediment was being transported by a stream, would have tended to increase the deposition of sediment and thus possibly affect the distribution of sedimentation. Only the general or overall distribution will be considered in this study. Spatial variations of causative factors will most often be considered on a county unit basis. Because of limited data, the consideration of intracounty variations is in many cases beyond the scope of this general analysis.

The pre-European Georgia Piedmont was like an erosional tinderbox awaiting the spark of man's misuse of the land. A generally erodable soil underlain by deeply weathered saprolite, steep slopes, and intense rainfall made up the stage on which man planted great expanses of row crops. Slopes which today are recognized as best suited for forest were extensively and often carelessly cultivated. The problem was compounded by widespread tenancy and a general lack of conservation practices. The results were severe losses of topsoil and dramatic gullying. Even today, the landscape of the Study Area is marred by deep gullies and vast areas on which the remaining subsoil will support only limited plant life. Most eroded land in the Study Area, however, is now under some vegetative cover. The spatial association of the areas of intense erosion and the areas of severe sedimentation will now be considered.

The Relation of Erosion to Sedimentation in the Study Area

Studies of accelerated sedimentation in the Southeast have shown that by 1940, most erosional debris had accumulated within approximately ten miles of the point of origin.[1] A small-scale map of the distribution of erosion would therefore appear to be fairly coincident with the distribution of sedimentation. Figure 11 shows the distribution of erosion in the Study Area, *circa* 1945. Because streams in the Study

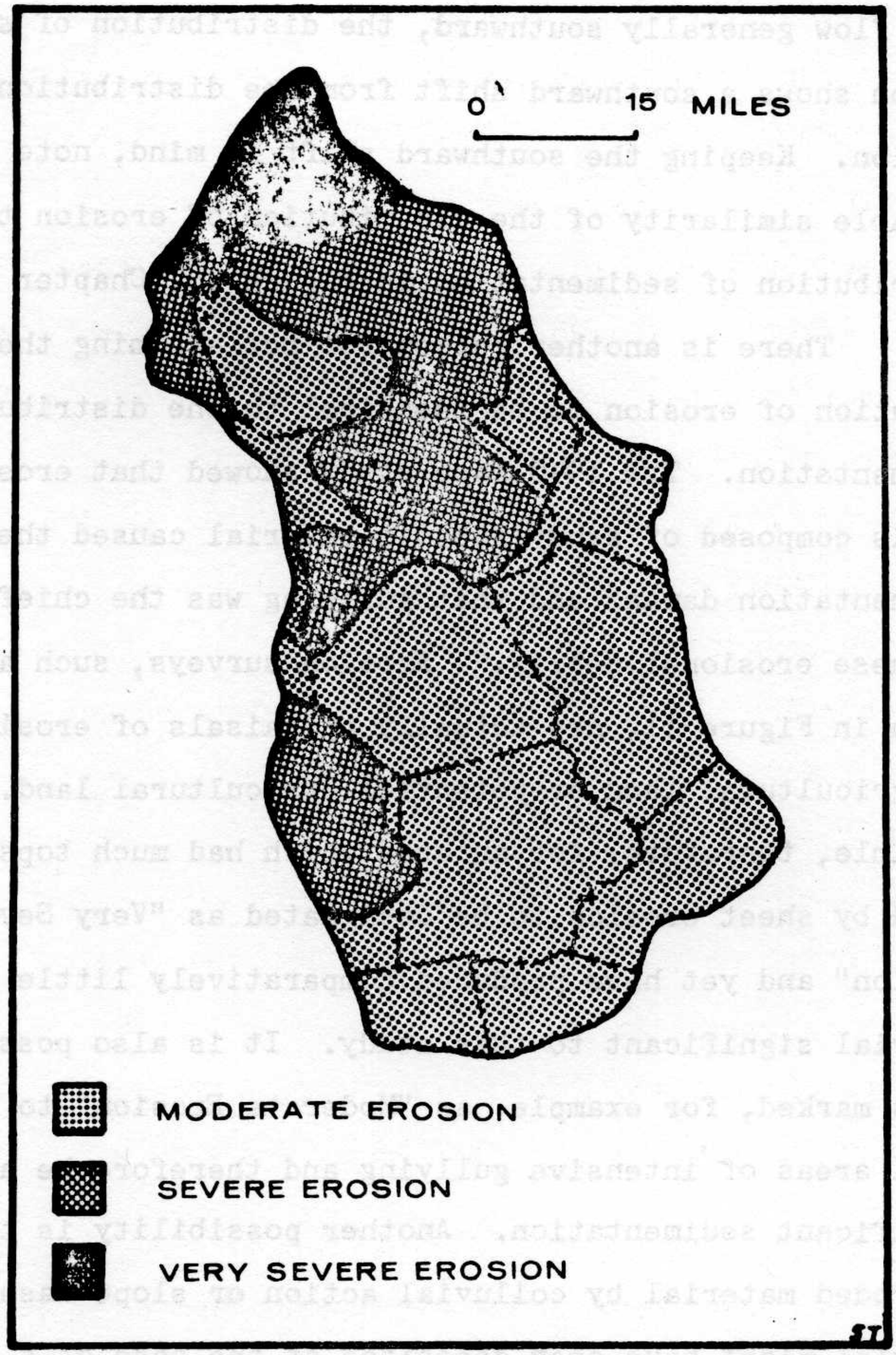


Figure 11. Generalized Erosion in the Study Area, circa 1945. Source: Postwar Planning Atlas, Southeast Region, U. S. Department of Agriculture.

Area flow generally southward, the distribution of sedimentation shows a southward shift from the distribution of erosion. Keeping the southward shift in mind, note the remarkable similarity of the distribution of erosion to the distribution of sedimentation in Figure 10, Chapter Two.

There is another reason for not assuming the distribution of erosion to be identical to the distribution of sedimentation. The 1940 Happ study showed that erosional debris composed of sandy subsoil material caused the most sedimentation damage and that gullying was the chief source of these erosional debris.[2] Erosion surveys, such as that shown in Figure 11, are actually appraisals of erosion damage to agricultural land or potential agricultural land. It is possible, therefore, for an area which had much topsoil removed by sheet erosion to be designated as "Very Severe Erosion" and yet have produced comparatively little sediment material significant to this study. It is also possible for areas marked, for example, as "Moderate Erosion" to have local areas of intensive gullying and therefore be an area of significant sedimentation. Another possibility is the removal of eroded material by colluvial action or slope wash. Such material might have been deposited at the base of a slope and never have found its way to a stream channel.[3] Despite these erosional possibilities, the distribution of erosion, as has already been demonstrated, gives a satisfactory approximation of the distribution of sedimentation. Therefore, this study will proceed to analyze the distribution of sedimentation through a consideration of the factors of erosion.

The Relation of the Distribution of Culturally Accelerated Sedimentation in the Study Area to the Factors of Soil Erosion

It should be kept in mind that this chapter is not simply a study of the causes of erosion, but is a geographical analysis of a large watershed to ascertain which factors of erosion probably played the more significant roles. It is realized that the determination of importance of erosional factors is still a controversial field of study and it is not the purpose of this study to enter into these controversies. Rather, practical erosional data which have been empirically evolved by the Agricultural Research Service of the U. S. Department of Agriculture are utilized.[4] As noted in the Introduction, the type and extent of land use have been ascertained by most investigators to have been the most important factors contributing to accelerated sedimentation. It is therefore a major goal of this chapter to demonstrate how closely the distribution of erosive land use coincides with the distribution of modern sedimentation.

Factors of Soil Erosion Caused Primarily by Rainfall

Soil conservation scientists have been making concentrated efforts since 1929 to ascertain the factors of soil erosion caused primarily by rainfall and to measure the influence of each of these factors. By 1961, an empirical equation had been developed which permitted predictions of soil erosion at any point.[5] Technical publications have been prepared to allow the use of this equation in individual geographical areas of the United States.[6]

This equation reflects the influence of all the major factors known to influence rainfall erosion.[7] The equation is A = RKLSCP where:

<u>A</u> is the average annual soil loss in tons per acres predicted by the equation.

<u>R</u> is the rainfall factor.

<u>K</u> is the soil erodability factor.

<u>LS</u> is the length and steepness of slope factor.

<u>C</u> is the cropping and management factor.

<u>P</u> is the supporting conservation practice factor.

As indicated, the equation is designed to be used for a finite soil loss prediction at a given geographical point. In order to apply the equation to an area, all factors must be considered abstractly rather than finitely. Therefore, <u>A</u> will vary spatially as a relative value instead of a definite amount of soil loss. Each factor will be considered in a spatial context in order to examine the association of each factor with sedimentation. The three physical factors of erosion, rainfall, soil erodability, and slope, are considered first in order to set the natural stage for man's role.

<u>The Rainfall Factor, R</u>.--<u>R</u> is defined as the kinetic energy of a rainfall times the maximum thirty minute intensity.

The product obtained is "the truest indicator yet developed to measure the potential of rainfall to cause erosion from cultivated fallow soil."[8] R is given as an index number which has great variation throughout the United States and the Southeast.[9] Figure 12 shows the distribution of R values for the Study Area. Note that with the exception of several isolated Type 1 and 2 sedimentation concentrations, the distributions of sedimentation and of R factors are quite similar.

The Soil Erodability Factor, K.--This factor reflects the fact that different types of soil erode at different rates when the other factors affecting erosion are constant. There are seven significant soil associations in the Study Area, all basically of the Cecil-type soils.[10] With one areally small exception, all of the soil associations in the Study Area have the same K or erodability factor.[11] The only exception to this soil type uniformity is an area of a few thousand acres in Greene County which has a slightly higher K factor. This area of more erodable soil is approximately coincident with the area of Type 1 sedimentation on Richland Creek in Greene County.

Another consideration in evaluating soil erodability is that as a soil is eroded away, it tends to erode at a faster rate. That is, the subsoil and parent material in the Study Area erode at a faster rate than the topsoil. Thus, areas which were more heavily eroded, as shown on Figure 11, tended to erode faster than less eroded areas. The distribution of

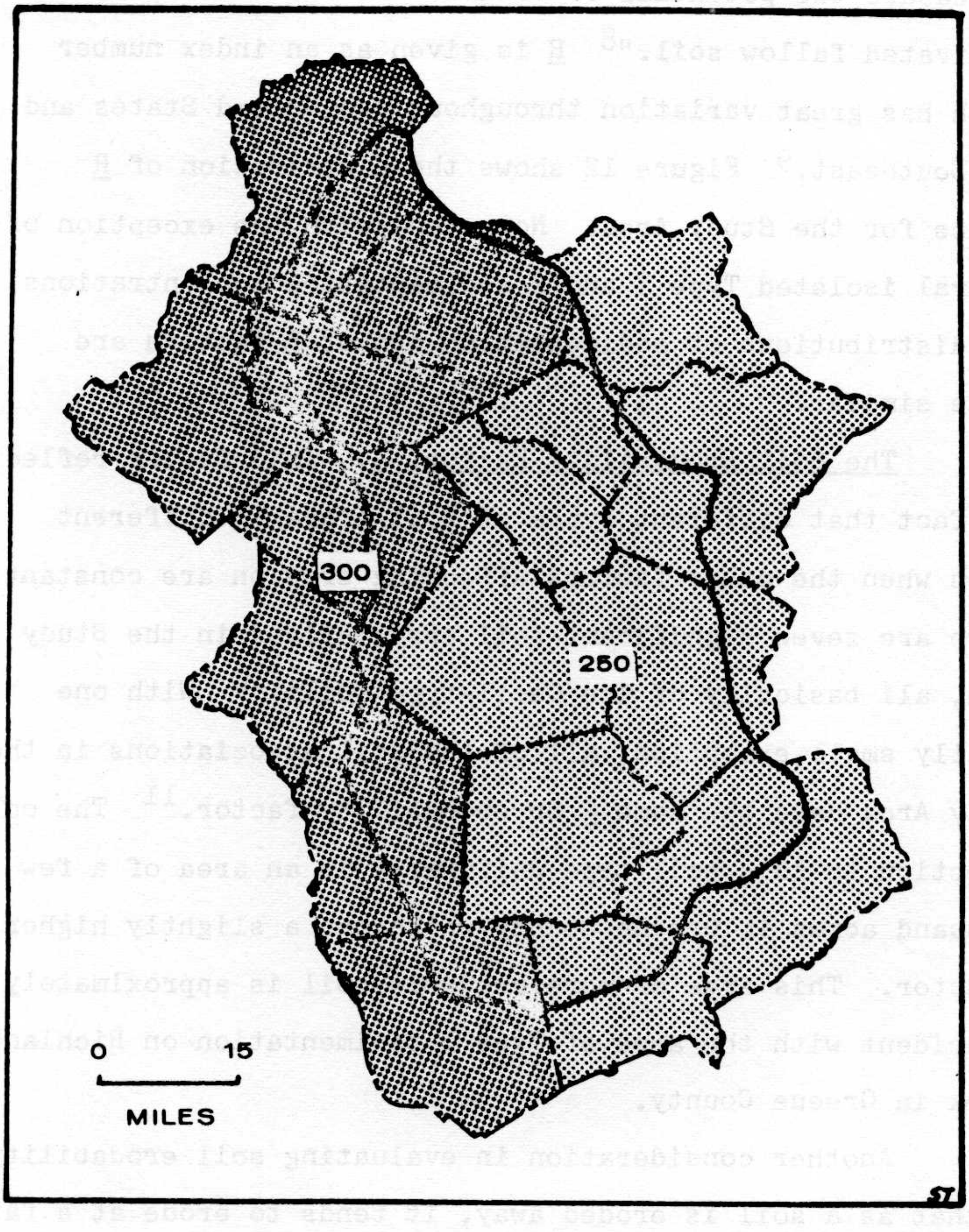


Figure 12. Rainfall-Erosion Index by County. Source: U. S. Department of Agriculture, Soil Conservation Service, "Soil Loss Prediction for Georgia," 1963.

erosion shown would have tended to reinforce itself. Thus, the distribution of the K factor varies with the distribution of erosion which, in turn, has been shown to be closely coincident with the distribution of sedimentation. Unfortunately, there is no way to give quantitative significance to this variation in erosion rates caused by previous erosion.

The Length and Steepness of Slope Factor, LS.-- Research extending back to 1929 shows that soil loss per unit area increases at an increasing rate with slope length and steepness of slope.[12] The importance of slope to erosion has been demonstrated in tests in the Study Area at Watkinsville, Georgia, by the U. S. Department of Agriculture. Under otherwise identical conditions, an increase of slope from 3 per cent to 7 per cent caused the soil loss from continuously cropped cotton to increase by ten times.[13] Since this study is intended as a spatial analysis, it is impossible to use specific numbers for length and steepness of slope. The factor must be evaluated by considering the physiography of the Study Area. A breakdown of percentages of land in various slope classifications is not available for the entire Study Area. Neither is there complete coverage of U. S. Geological Survey 1:24,000 topographic maps. Therefore, a qualitative analysis must be made by means of field observation and U. S. Geological Survey 1:250,000 topographic maps.[14]

The Study Area is a river basin which slopes from maximum elevations of 1,100 feet in the north to 500 feet in the south. The northern extreme is highly dissected, with relief decreasing to the south. Dissection also increases somewhat near the rims of the basin and near the larger streams. The interfluve areas tend to be broader and flatter towards the south. These broader interfluves are especially apparent in Putnam County and are noticeable in Morgan and Oconee Counties. There is thus more land of moderate slope available for crops in the south-central portion of the Study Area while areas in the north and, to a lesser degree, near the rims have a higher percentage of the land in steep slopes and have less land suitable for cropping. For example, the portion of Hall County in the Study Area has much less land in gentle slopes than does Oconee, Morgan, or Putnam Counties. A large percentage of land in row crops would, other conditions being equal, cause far more erosion in Hall County than in Oconee, Morgan, or Putnam Counties. Very steep slopes and very severe erosion are coincident in the north, but there is less spatial association between steep slopes and erosion in the remainder of the Study Area.

In general, the spatial distributions of the natural erosive factors are reasonably similar to the distribution of sedimentation. The distribution of the more erosive values of the rainfall factor and of the soil erodability factor appears to coincide well with the distribution of sedimentation. Areas of steeper slopes seem to be associated with sedimentation in the northern portion of the

Study Area. There is, however, some dissimilarity between the relatively greater dissection along the Oconee River in the southeastern portion of the Study Area and the lack of sedimentation in that area. It is important to note, however, that none of these natural factors would have contributed much to erosion and sedimentation unless man had first cleared the land and exposed the soil to erosion by row crops and poor conservation practices.

Man's Role in Accelerating Erosion and Sedimentation

Previously cited studies have shown that investigators of accelerated stream sedimentation were aware of man's role in accelerating erosion and consequent stream sedimentation. A 1917 study in Georgia perceptively noted that on the Piedmont:

> Excepting for occasional tracts of woodland nearly all of the hill land is cultivated almost entirely with clean-cultivated crops. This fact and the fact that much of the cultivation is done on the tenant system . . . a system which always tends toward deterioration of the land--are in large measure responsible for the present poor drainage conditions along the streams.[15]

Thus, investigators of the early twentieth century recognized the cause of the accelerated sedimentation of Piedmont streams. Even now, aged farmers in the Study Area who remember streams in their pre-sedimented state and who witnessed the soil being swept from clean-cultivated hillsides, have no doubts as to what caused accelerated erosion. This destructive man-land relationship has been such an accepted part of their experience that they find nothing remarkable about it. Knowledgeable residents of the Study Area as well as previous investigators of sedimentation have already declared man to be responsible for accelerated sedimentation. This study, therefore, will demonstrate the spatial association of erosive land use and accelerated sedimentation. Land use and soil conservation, the two remaining components of the soil erosion equation, will now be considered.

The Cropping and Management Factor (Land Use), C.--The land use factor is difficult to evaluate because of the many ways that land can be cropped and managed and because of other considerations such as rate and amount of crop growth. Especially conducive to erosion are row, or clean-cultivated, crops such as cotton and corn. Tests by the U. S. Department of Agriculture in the Study Area at Watkinsville, Georgia, have shown that, under identical conditions, soil losses from continuously grown cotton were from 12 to 134 times as great as from conservatory crops.[16]

In the late nineteenth century, acreages in corn and cotton were rapidly expanded in the Study Area as shown in the land-use graph, Figure 13. The expansion of row crop land continued until circa 1919 when approximately 40 per cent of the Study Area was being cropped to cotton and corn. Because of the boll weevil and low prices, acreages of cotton dropped sharply after 1920 and have generally decreased since that time. In the same period when land in

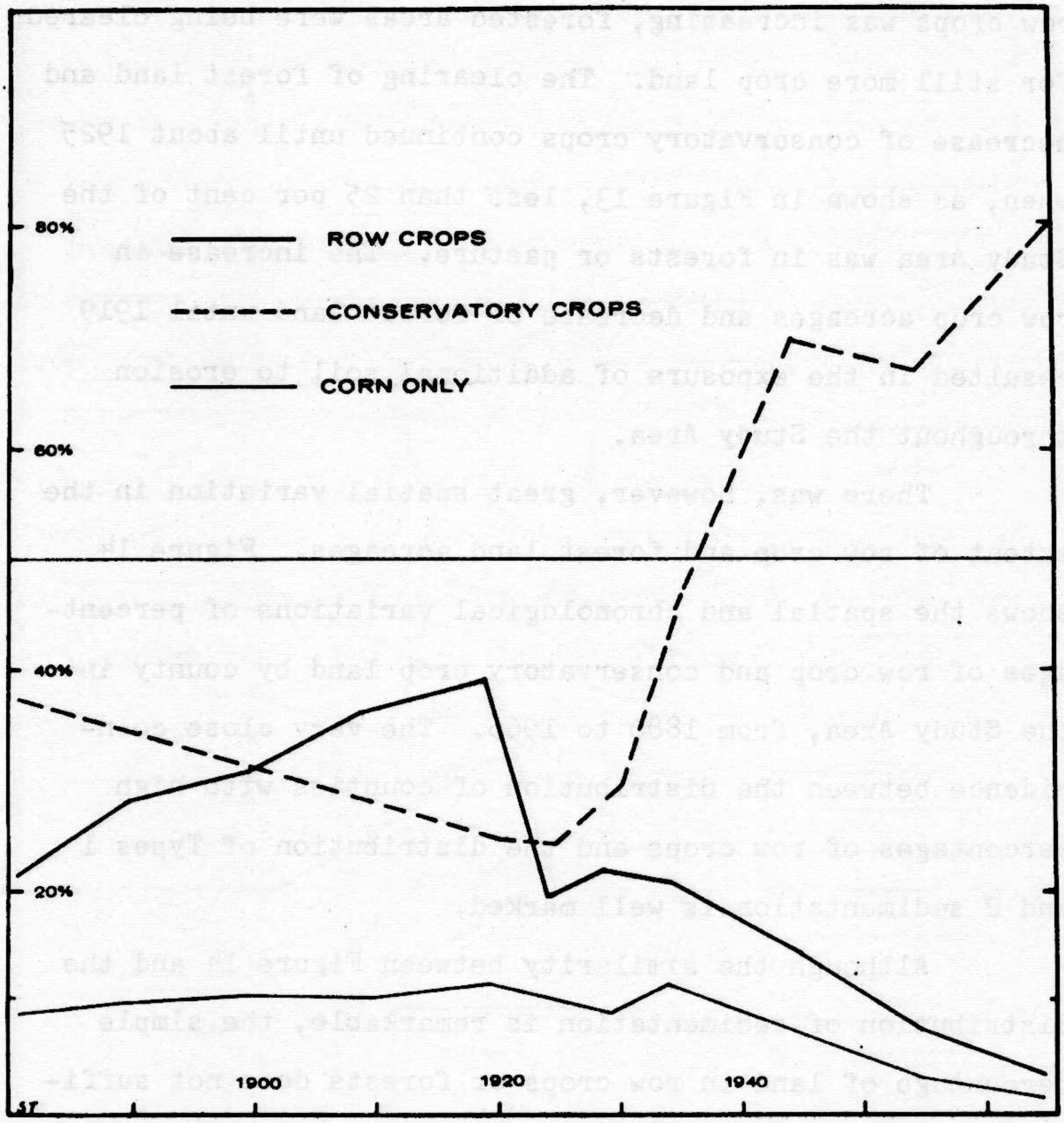


Figure 13. Percentages of Study Area in Erosive and Conservatory Crops, 1880-1966. "Row Crops" include corn, cotton, soybeans, and sorghum. "Conservatory Crops" include forests, pasture, and Lespedeza. Sources: 1880-1954, U. S. Census of Agriculture; 1966, U. S. Department of Agriculture, Soil Conservation Service.

row crops was increasing, forested areas were being cleared for still more crop land. The clearing of forest land and decrease of conservatory crops continued until about 1925 when, as shown in Figure 13, less than 25 per cent of the Study Area was in forests or pasture. The increase in row crop acreages and decrease of forest land until 1919 resulted in the exposure of additional soil to erosion throughout the Study Area.

There was, however, great spatial variation in the extent of row crop and forest land acreages. Figure 14 shows the spatial and chronological variations of percentages of row crop and conservatory crop land by county in the Study Area, from 1880 to 1966. The very close coincidence between the distribution of counties with high percentages of row crops and the distribution of Types 1 and 2 sedimentation is well marked.

Although the similarity between Figure 14 and the distribution of sedimentation is remarkable, the simple percentage of land in row crops or forests does not sufficiently describe the significance of land use in contributing to soil erosion. Instead, as acreages of cropland increase, erosion and consequent sedimentation increase at an increasing rate. This concept may be demonstrated by considering Oconee County which has 31.4 per cent of its total land area in land of 0-6 per cent slopes and 30.5 per cent in 6-10 per cent slopes.[17] In 1919, as shown on Figure 14, 51 per cent of the total land area of Oconee

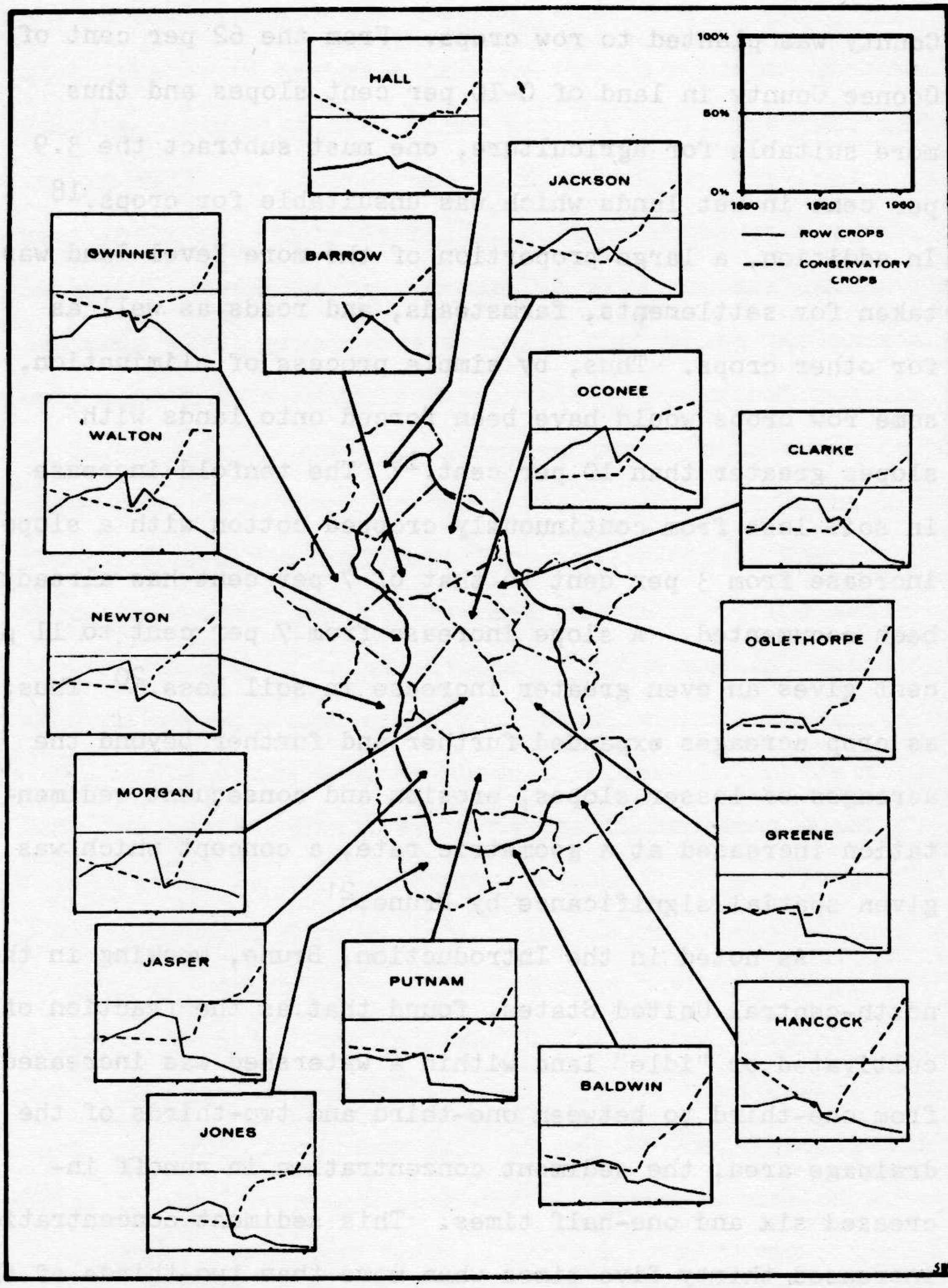


Figure 14. Percentages of Study Area Counties in Erosive and Conservatory Crops, 1880-1966. Sources: 1880-1954, U. S. Census of Agriculture; 1966, U. S. Department of Agriculture, Soil Conservation Service.

County was planted to row crops. From the 62 per cent of Oconee County in land of 0-10 per cent slopes and thus more suitable for agriculture, one must subtract the 3.9 per cent in wet lands which was unsuitable for crops.[18] In addition, a large proportion of the more level land was taken for settlements, farmsteads, and roads as well as for other crops. Thus, by simple process of elimination, some row crops would have been forced onto lands with slopes greater than 10 per cent.[19] The tenfold increase in soil loss from continuously cropped cotton with a slope increase from 3 per cent to that of 7 per cent has already been documented. A slope increase from 7 per cent to 11 per cent gives an even greater increase in soil loss.[20] Thus, as crop acreages expanded further and further beyond the acreages of lesser slopes, erosion and consequent sedimentation increased at a geometric rate, a concept which was given spatial significance by Brune.[21]

As noted in the Introduction, Brune, working in the north-central United States, found that as the fraction of cultivated or "idle" land within a watershed was increased from one-third to between one-third and two-thirds of the drainage area, the sediment concentration in runoff increased six and one-half times. This sediment concentration increased thirty-five times when more than two-thirds of the drainage area was cultivated or idle.[22]

Because no data such as those derived by Brune are available for the Study Area, his data are assumed to be applicable to the Study Area in order to illustrate the significance of the role of land use as a factor in accelerating sedimentation. Using Brune's data, the information on Figure 14 is transformed to give the hypothetical sediment yield by county from 1880 to 1966 shown on Figure 15. Because no detailed transformation data are available, the sediment yield graphs are actually controlled sketches and only approximate Brune's data. Also, the transformation is based only on row crop acreages rather than total cultivated and "idle" land as Brune used. Although Brune's data have been applied uniformly for each county in the Study Area, this would not be the case in reality. The sediment yields would have to be adjusted for the spatial variations of soil conservation practices, physiography, and rainfall.

The Study Area as shown in Figure 15 may be divided into two parts. The area to the north and west which includes Hall, Gwinnett, Barrow, Jackson, Clarke, Oconee, Walton, Newton, Morgan, and Jasper Counties may be termed an area of higher hypothetical sediment yield. Hall and Gwinnett Counties are included in this area because of their relatively greater area in slopes. The area to the east and south including Oglethorpe, Greene, Putnam, Hancock, Baldwin, and Jones Counties may be termed an area of lower hypothetical sediment yield. Overall, the resemblance of the distribution of hypothetical sediment yield is remarkably similar to the distribution of sedimentation.

There is still further significance to the land use factor. The boll weevil, low cotton prices, and other

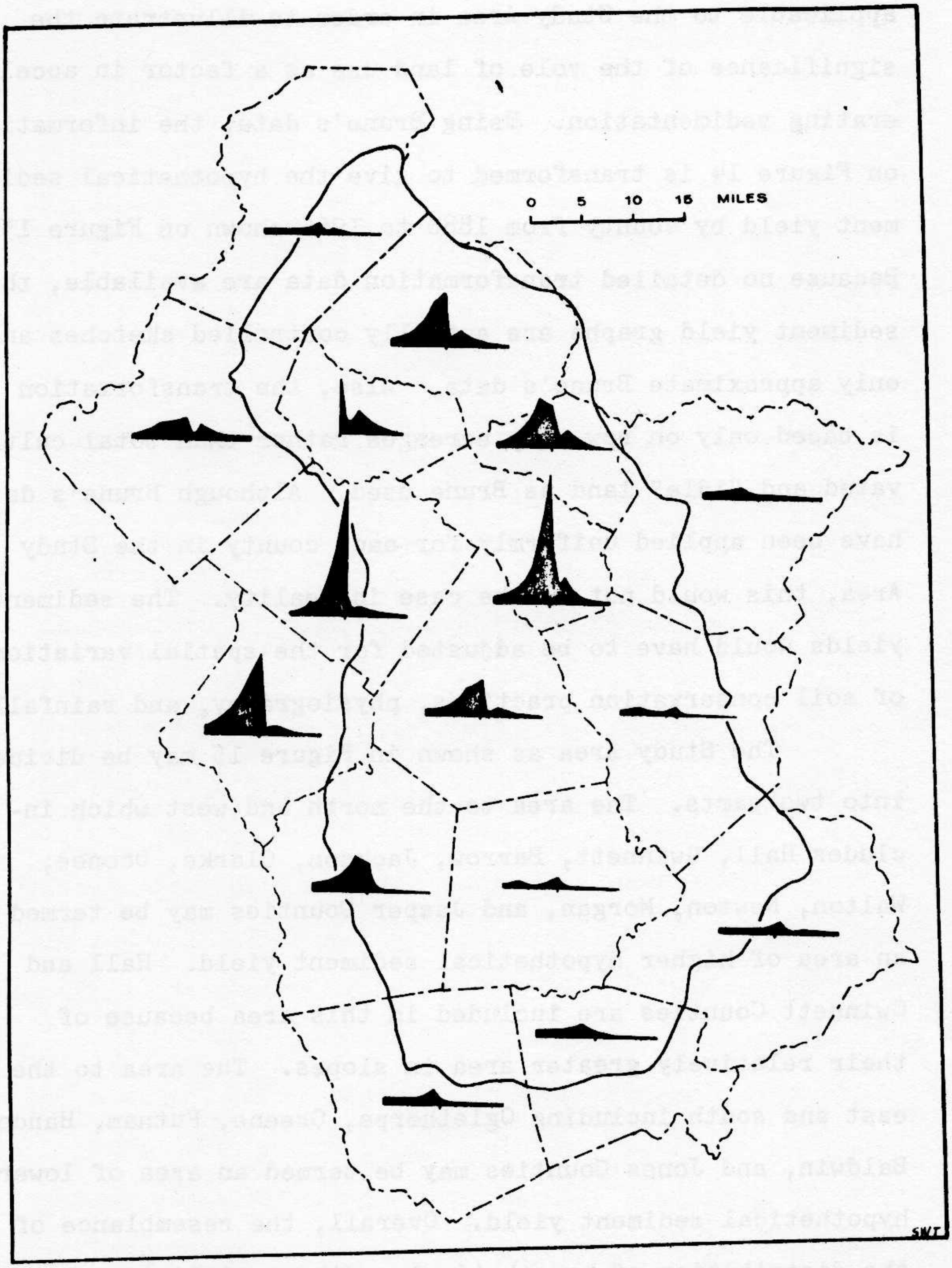


Figure 15. An Hypothetical-Chronological Distribution of Relative Sediment Yield Per Unit Area, by County, 1880-1966. The Index Mark at the Base of Each Graph Denotes the Year 1920.

factors caused much of the extensively cleared and cultivated land to be abandoned during the 1920's. Such abandoned land was left to erode and often, to gully.[23] Willard Range, a Georgia agricultural historian, noted that during the early 1920's in upland (Piedmont) Georgia, "thousands of landlords, tenants, and wage hands were deserting farming entirely, leaving the land to weeds and gullies."[24]

Raper eloquently pictures much of the Greene County landscape of the 1920's:

> All around were abandoned fields. Much of the land was spent, too tired to cover itself with grass or weeds during the summer. Dead cotton and corn stalks weathered one winter and came to the next, ground frost spewed loose their dead roots, March winds blew them over, and that year the heavy rains, which always come, washed more loose dirt than ever before into the creeks and rivers of Greene. The next winter and summer, and the next and the next, saw more dirt leave from the least fertile parts of once active fields.[25]

Jackson Bennett, veteran Soil Conservation Service Soil Scientist, recently completed a study of a small plot of old abandoned land on the Greene-Oconee County line. He concluded:

> The subject area, which originally had a Cecil Sandy Loam soil with a slope ranging from 11 to 15 per cent is located on an interfluve or upland site in Greene County, Georgia. In 1900 it was cleared of the original woods, a mixture of native hardwood and pine trees. The field, of which the plot is only a small part, was cultivated continuously until 1930, at which time it was abandoned as waste land. The history of the field since 1900 parallels that of much of the more severely eroded Georgia Piedmont sections; first <u>original woods</u>; second,

> cultivation to clean tilled cotton and corn crops annually; then finally, abandonment because of unsuitability for further agricultural use because of gullying and reduced productivity level.[26]

This highly eroded plot of .15 acre has lost soil at an average annual rate of 90.4 tons per acre since 1900. Such eroding and gullying land, once planted to cotton and corn, was responsible for much of the sedimentation present today in the Study Area. Plates I and II portray much of the abandoned land in the Study Area as it appeared in the 1920's.

The Conservation Practices Factor, P.--Conservation Practices were introduced in Georgia long before 1900, but found limited acceptance until the late 1930's.[27] There are no records regarding the number of acres under conservation practices during the period of extensive row cropping. Range gives a clue to the distribution of implemented conservation practices during the early part of this century by noting that tenant farmers were much more negligent than farm owners in the care of the soil and in the implementation of soil conservation practices.[28] Therefore, one indirect measurement of the distribution of conservation practices, or lack of such practices, is the distribution of tenancy. Tenancy was computed for the Study Area by county on the basis of tenant farm acreage as a percentage of total farm acreage.[29] Because percentages of tenancy varied relatively little between censuses, the average county tenancy rate as computed from the 1910, 1920, 1925, 1930, 1935, and 1940

PLATE I

PLATE I.--Although this photograph was taken on the South Carolina Piedmont, it portrays a scene of abandoned land which would have been frequently encountered in the Study Area during the 1920's and 1930's. (Soil Conservation Service Photograph.)

PLATE II

PLATE II.--This abandoned tenant house and eroding land is typical of much of the Study Area in the 1920's and 1930's. Source: Arthur F. Raper, <u>Tenants of the Almighty</u>, (New York: 1943).

censuses of agriculture was used as the tenancy figure in Figure 16. Note that there is little resemblance between the incidence of higher tenancy rates and that of sedimentation. Keeping the detrimental effects of tenancy in mind, Figure 16 appears to indicate that there was a relatively greater lack of implemented soil conservation measures in the west-central portion of the Study Area. Therefore, there would probably have been a corresponding increase of the erosive effects of clean-cultivated crops in that area.

In general, a remarkable correspondence between the distributions of several soil erosion factors and the distribution of sedimentation in the Study Area has been demonstrated. The distributions of significant natural erosion factors such as soil erodability, rainfall, and slope are fairly similar to the distribution of sedimentation. The role of the natural factors, however, is insignificant until man or some other force has laid the soil bare to erosion. The most important factor of erosion and sedimentation has been type and extent of land use with soil conservation practices having served to modify the effects of land use. This conclusion is in agreement with previous studies which have already been noted.

Factors Which Would Have Increased Sedimentation Once the Erosional Material Was Being Transported by A Stream

This chapter has thus far examined the spatial variation of erosional factors which would have caused the soil

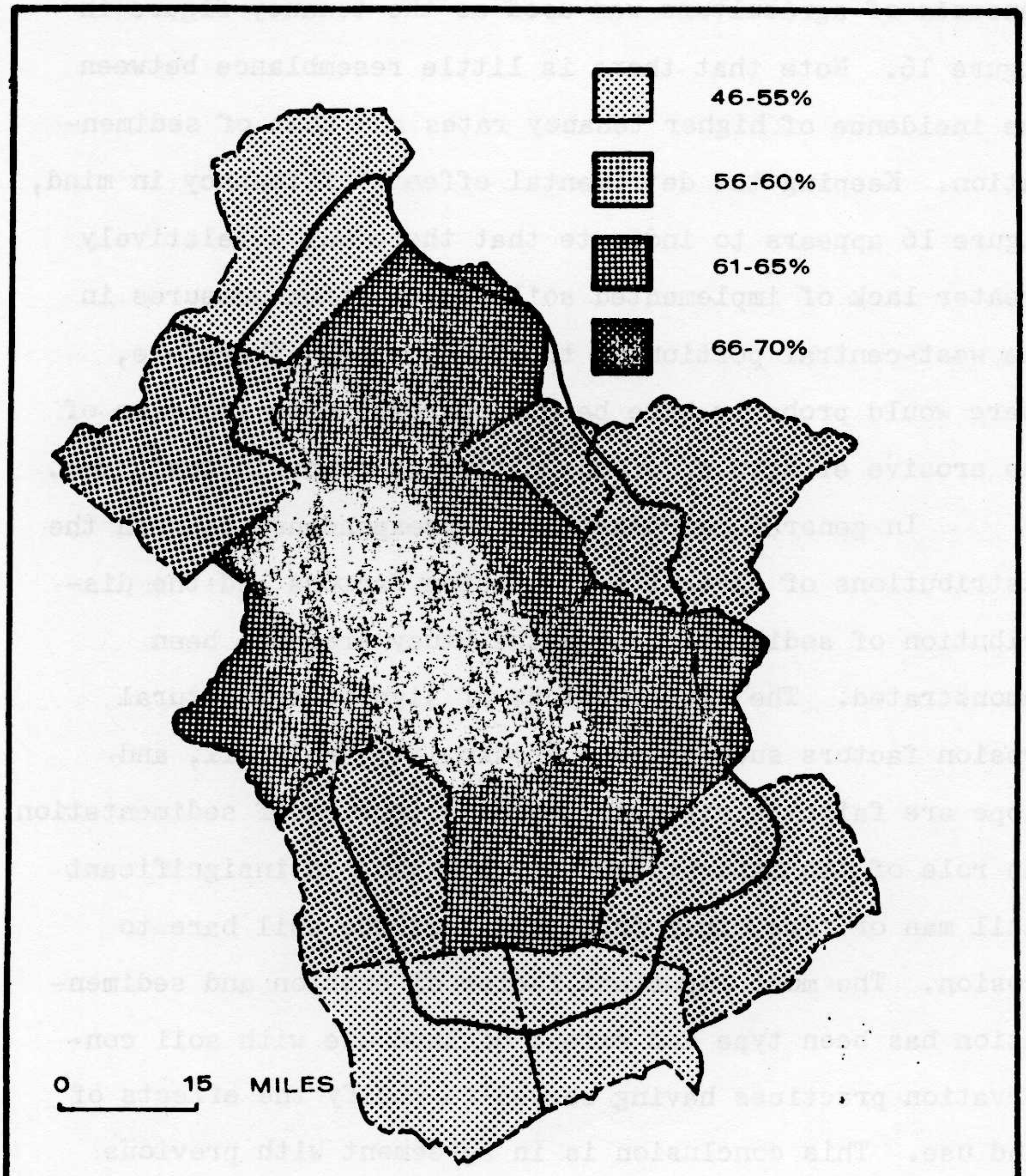


Figure 16. Tenancy by County in the Study Area, 1910-1940, Expressed as a Percentage of Total Farm Acreage. Source: U. S. Census of Agriculture.

particles to be removed from the source. Most of these particles would then have been entrained by flowing water and moved some distance. The focus of this study will now be on factors which would have caused the deposition of these entrained sediments. These deposition factors would have, in most cases, played a minor part in determining the small scale distribution of sedimentation. Happ concluded that most of the coarse sediment materials carried as bedload by streams were within approximately ten miles of the source. Thus, as previously noted, there should be only minor differences in the distributions of erosion and sedimentation at a scale of 1:500,000 or smaller. There is, however, another factor which must be considered. Deposition factors which would have caused the deposition of stream bedload might also have caused the deposition of suspended sediment load, which is normally carried much faster and further than bedload. Thus, deposition factors possibly had a noticeable effect in increasing local intensity of sedimentation.

Millponds and Reservoirs As A Cultural Deposition Factor

Millponds and reservoirs tended to increase deposition by creating an artificial channel plug.[30] This increase in sedimentation was usually only felt in a small area upstream from the dam, although larger areas were sometimes affected. The effectiveness of a millpond as a sedimentation factor depended in part on the amount of sediment material being transported by the stream. Many mills in the northern portion of the Study Area were actually overwhelmed by the amount of sedimentation and had to be abandoned, whereas millponds in areas of less sedimentation, such as Putnam County for example, were occasionally drained to permit the accumulated sediment to wash through. Generally, mills in the southern portion of the Study Area were able to operate until conditions other than sedimentation caused their abandonment.[31] Figure 7, Chapter Two, shows millponds which underwent intensive sedimentation and thus were factors in localizing deposition. Notwithstanding the higher original density of millponds in the northern portion of the Study Area, the northward concentration of mills rendered inoperable or inefficient is probably more significant as an <u>effect</u> of sedimentation rather than as a <u>cause</u>.

<u>Consideration of Some Natural Deposition Factors</u>

It has already been noted that low, wide valley floors would have suffered more from a given amount of sedimentation than V-shaped valleys. These low, wide valleys usually, but not always, occur with low stream gradients. Low stream gradients, or pools, are a localizer of deposition and play only a small part in influencing the overall small scale distribution of sedimentation.

Streams may also be naturally dammed by logs and other debris. Such a dam is usually temporary, although it may be permanent. No significant areas of sedimentation known to be originally caused by such obstructions were encountered in the course of this study. Trees, logs, and other debris buried in sediment deposits tend to act as reinforcement and often will not permit a stream to degrade itself. Unfortunately, there is no dependable way to ascertain the location of either low stream gradients or of natural obstructions in the Study Area and consequently, there is no way to map their distribution.

There is another natural deposition factor, that of stream order dominance. As has been emphasized in this study, the coarse sediment materials significant to this study were initially deposited in headwater or lower-order streams while larger streams suffered relatively less sedimentation. Therefore, if other conditions are equal, areas having a lower-order stream dominance should have undergone more sedimentation than areas with a higher-order stream dominance. Unfortunately, the lack of topographic map coverage precludes the determination of the spatial variation of stream order dominance for the Study Area. A cursory glance at the stream pattern of the Study Area indicates that there may be a predominance of lower-order streams in the northern and western portions of the Study Area. It would seem that the larger streams tend to occupy the eastern portion of the basin. Because no quantitative or qualitative significance can be given to the spatial variation of stream order dominance in the Study Area, it will not be pursued in this study.

Conclusions

The distribution of sedimentation seems to have been most influenced by type and extent of land use, a conclusion which tends to reinforce previous non-geographical studies. The lack of soil conservation practices intensified the effects of extensive clean-cultivated crops. The distribution of tenancy, the criterion utilized to measure lack of implemented soil conservation practices, indicated that soil conservation practices were less prevalent in the central and western portions of the Study Area. Secondary erosion factors appear to be rainfall, the variation in soil erodability caused by previous erosion, and proportion of land area in slopes. Deposition factors such as milldams and reservoirs, natural debris in stream channels, and low stream gradients all seemed to have a mainly local effect. Their effect on the overall distribution at a small scale was relatively minor.

NOTES

[1]Stafford C. Happ, Gordon Rittenhouse, and G. C. Dobson, Some Principles of Accelerated Stream and Valley Sedimentation, U. S. Department of Agriculture Technical Bulletin No. 695, (Washington: 1940), p. 116.

[2]Ibid., pp. 75, 86, 95.

[3]Arthur N. Strahler, "The Nature of Induced Erosion and Aggradation," in William L. Thomas (ed.), Man's Role in Changing the Face of the Earth, (Chicago: 1956), pp. 630-631.

[4]U. S. Department of Agriculture, Soil Conservation Service, "Soil Loss Prediction for Georgia," June 26, 1963. This manual is based on a soil loss equation formulated by W. H. Wischmeier and D. D. Smith, "A Universal Soil-Loss Estimating Equation to Guide Conservation Farm Planning," Transactions of the Seventh Congress of the International Soil Science Society, 1961.

[5]U. S. Department of Agriculture, Agriculture Research Service, A Universal Equation for Predicting Rainfall-Erosion Losses--An Aid to Conservation Farming in Humid Areas, Agriculture Research Service Special Report 22-66, March, 1961.

[6]The publication consulted for this study is "Soil Loss Prediction for Georgia," supra.

[7]"A Universal Equation . . . ," p. 3.

[8]Ibid., p. 4.

[9]For a map of R values or "Iso-erodents" in the eastern United States, see W. H. Wischmeier, "Storms and Soil Conservation," Journal of Soil and Water Conservation, March-April, 1966, p. 58.

[10]H. F. Perkins and F. T. Ritchie, Soil Associations of Georgia, Georgia Agricultural Experiment Stations, University of Georgia, College of Agriculture, and U. S. Department of Agriculture, April, 1965.

[11]"Soil Loss Prediction for Georgia," pp. 11-15.

[12]"A Universal Equation. . . ," pp. 5-9.

[13]B. H. Hendrickson, A. P. Barnett, J. R. Carreker, and W. E. Adams, Runoff and Erosion Control Studies on Cecil Soils on the Southern Piedmont, Technical Bulletin No. 1281, Agriculture Research Service, U. S. Department of Agriculture, April, 1963, p. 18.

[14]U. S. Geological Survey 1:250,000 Topographic Maps Athens, Georgia; South Carolina; 1953, and Greenville, South Carolina; Georgia; North Carolina; 1958.

[15]H. H. Barrows and J. V. Phillips, Agricultural Drainage in Georgia, Georgia Geological Survey Bulletin No. 32, (Atlanta: 1917), p. 14.

[16]B. H. Hendrickson, et al, Runoff and Erosion Control. . ., pp. 23-24.

[17]U. S. Department of Agriculture, Soil Conservation Service, Soil Survey of Clarke and Oconee Counties, Georgia, November, 1968, p. 6.

[18]See Figure 4.

[19]This statement has been corroborated by the testimony of many older residents in the Study Area. The fact that steep slopes were cultivated is clearly written on the landscape. Terraces from old cotton fields may even now be seen on slopes of 15 per cent and greater. Most of these slopes are now covered with trees.

[20]Hendrickson, et al, p. 19.

[21]Cited in Luna B. Leopold, "Land Use and Sediment Yield," in William L. Thomas, Jr. (ed.), Man's Role in Changing the Face of the Earth, (Chicago: 1956), p. 642.

[22]Ibid.

[23]This statement is made on the basis of the testimony of many residents living throughout the Study Area.

[24]Willard Range, A Century of Georgia Agriculture, (Athens: 1954), p. 174. See also p. 269.

[25]Arthur F. Raper, Tenants of the Almighty, (New York: 1943), p. 158.

[26]Jackson Bennett, "Soil Loss in Thompson Grove Plot, Greene County, Georgia," (Unpublished term paper, Geography Department, University of Georgia), p. 12.

[27]Range, <u>A Century of Georgia Agriculture</u>, p. 119.

[28]<u>Ibid</u>., p. 86.

[29]Tenancy acreage was not recorded before 1910 and is thus not considered. After 1940, tenancy declined so rapidly as to become insignificant for consideration.

[30]For the processes involved, see Happ, et al, pp. 72-74, 97-98. The investigator found at least three cases where the presence of milldams helped increase sedimentation over a considerable area. In all three cases there was a low stream gradient upstream from the mill sites.

[31]Perhaps significantly, the only water-powered mill still operating in the Study Area is the Millmore Mill on Shoulderbone Creek in Hancock County. This mill is located within the single area of Type 4 sedimentation. The owner states that there have been no sedimentation problems at this mill.

CHAPTER FOUR

THE ERA OF CONSERVATORY CROPS AND SOIL CONSERVATION 1940 TO THE PRESENT

Relief from the sedimentation problem began in the 1940's with the reduction of cropland, the increase of forest cover, and the implementation of soil conservation measures. All of these diminished erosion and consequent sediment load in the Study Area. As illustrated in Chapter Three, the decline of row crop acreage actually began in about 1920. Because much of the unused cleared land was simply abandoned to erode, the effects of the decline of row crops were not felt until much later when soil conservation measures were implemented. Presently, as shown in Figure 13, Chapter Three, only 3 to 4 per cent of the Study Area is in row crops. Corn is still grown throughout the Study Area, mostly in small scattered upland plots. Cotton, however, is found only in a limited number of upland enclaves. An example of a cotton enclave is found in Morgan and Walton Counties on the watershed of Big Sandy Creek. Field research indicated that Big Sandy Creek is still undergoing sedimentation from the erosion of the clean-cultivated fields.

The acreage of conservatory crops, mainly forest and pasture, began expanding in the period from 1925 to

1930. It has continued to expand until, by 1966, 80 per cent of the Study Area was under conservatory crops with forests predominating. The percentages, however, show considerable spatial variation. Walton County, for example, has only 67 per cent of the total area in conservatory crops while Hancock County has 91 per cent. Figure 14, Chapter Three, shows the present spatial variation of both row crops and conservatory crops.

Equally important in diminishing soil erosion and in the consequent decline in sedimentation are implemented soil conservation measures. The Soil Conservation Service of the U. S. Department of Agriculture is largely responsible for the ubiquity of implemented soil conservation practices in the Study Area. The Soil Conservation Service operations began in the Study Area in the middle 1930's.[1] Agents were assigned to each county to aid and advise farmers in terracing, contour plowing, stubble mulching, planning cover crops, and gully control, as well as other conservation measures.

The importance of gullies to sedimentation has already been noted. The control of gullies was possibly the one most significant conservation measure in diminishing sedimentation. For example, a gully in the Sandy Creek watershed north of Athens, surveyed in 1934, had had 37,700 cubic yards of material removed over a period of twenty-five years.[2] The removed material from this single gully, much of it coarse saprolite, would have been enough to fill a stream channel twenty-one feet wide and three feet deep for a distance of over one mile. The control of such gullies was effected by a combination of water and soil retention devices and soil conserving plants, particularly Kudzu.

Most Soil Conservation Service programs depend on the cooperation of the landowner and farmer. As the value of soil conservation has been recognized, increasing acreages of land in the Study Area have been effectively treated. A present program of the Soil Conservation Service is the Small Watershed Program which includes the prevention of soil erosion, the building of runoff retention dams to reduce sediment load and minimize flooding, and stream channel improvement to facilitate stream discharge. The result of soil conservation programs and changes in land use has been the great diminishment of field and hillside erosion. The problems remaining are those of roadside erosion and erosion from construction projects in which large areas of soil are cleared and exposed to rainfall.[3]

The greatly diminished erosion has meant a consequent diminishment of stream sediment load. The average turbidity rate (suspended sediment load) at Milledgeville on the mainstream Oconee River at the southern tip of the Study Area was 315 parts per million in 1939-40.[4] The subsequent damming of the river upstream from Milledgeville in 1952 would make present Milledgeville turbidity rates invalid for comparison, but the North Oconee River at Athens presently has an average turbidity rate of forty parts per million.[5] Although these two turbidity rates are from locations sixty-five miles apart and thus are not perfectly comparable, they do indicate the diminishment of erosion and consequent sedimentation in the Study Area.

This study has noted the fact that much of the coarse sediment material, primarily sand, was deposited in headwater valleys. These upstream deposits tended to steepen the longitudinal stream profile and thus became potentially unstable. As the 1940 Happ study stated, "These (headwater) deposits are potentially unstable and are subject to dissection and further downstream transportation."[6] In recent years, the competence of headwater streams has been increased by the greatly reduced sediment load. The consequently unstable sediment deposits are being reentrained and transported farther downstream where they are redeposited. At the Mauldin Millsite (Investigation Site 1, discussed in Chapter Two), there has been considerable degradation and the buried milldam was reexposed to view several years ago. As shown in Figure 17, the stream bed has degraded approximately seven feet from its highest level. Much of the degradation at this point has been caused by extensive removal of sand downstream. Plate III(a) is a recent photograph of the Mauldin milldam.

There are several significant effects of sediment migration. Valley floors along degrading streams may now be more easily drained and overflows are generally less

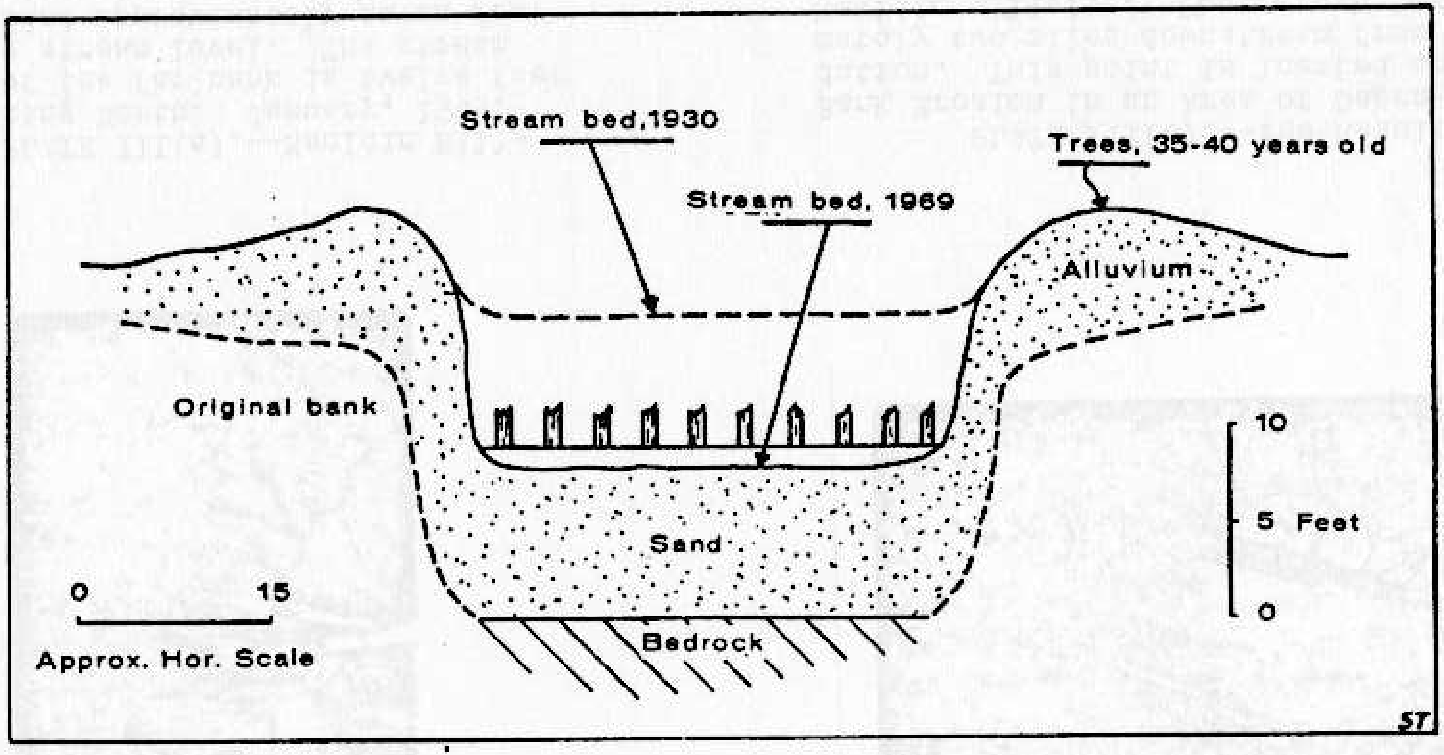


Figure 17. Mauldin Millsite, Investigation Site 1, Transverse Stream Profile at Dam, January, 1969.

PLATE III

PLATE III(a).--Mauldin Milldam, Looking North. January, 1969. The top of the far bank is twelve feet above the stream level. The stream has degraded approximately seven feet at this site since circa 1940.

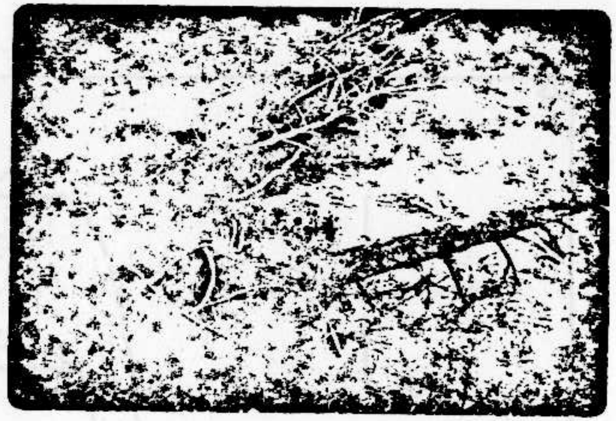


PLATE III(b).--The Result of Bank Erosion in an Area of Degradation. This point is located approximately two miles downstream from the Mauldin millsite. Photograph taken February, 1969.

likely. In addition to vertical degradation, there has been intensive erosion of the highly erodable sediment-formed banks. Large portions of stream banks have been eroded away taking trees, fences, and areas of good pasture or cropland. Plate III(b) is a photograph of the Mulberry River downstream from the Mauldin Millsite. Note the large trees which, having grown to maturity on the friable, natural levees of the river, have been recently undermined and as a result have fallen into the river.

Areas presently aggrading as a result of sediment migration are basically of two types, areas which have already undergone significant sedimentation and those areas which have undergone relatively little sedimentation. The former, areas which have undergone previous sedimentation, are characterized by reinforcement of sedimentation effects. Stream channels are further aggraded, there is more overbank deposition, and the area of wet land increases. Areas which simply were damp or marshy before the migration of sediment may now be covered by perennial lakes or ponds. The highway 11 bridge over the Middle Oconee River in Jackson County (Investigation Site 12, discussed in Chapter Two), is an excellent example of intensified sediment damage. Upstream tributaries are degrading and the reentrained sediments are presently being deposited in the mainstream channel. Portions of valley floor, covered by marsh in 1944, are presently covered by perennial lakes and ponds, as shown in Figure 18. Plate IV is a photograph taken from the

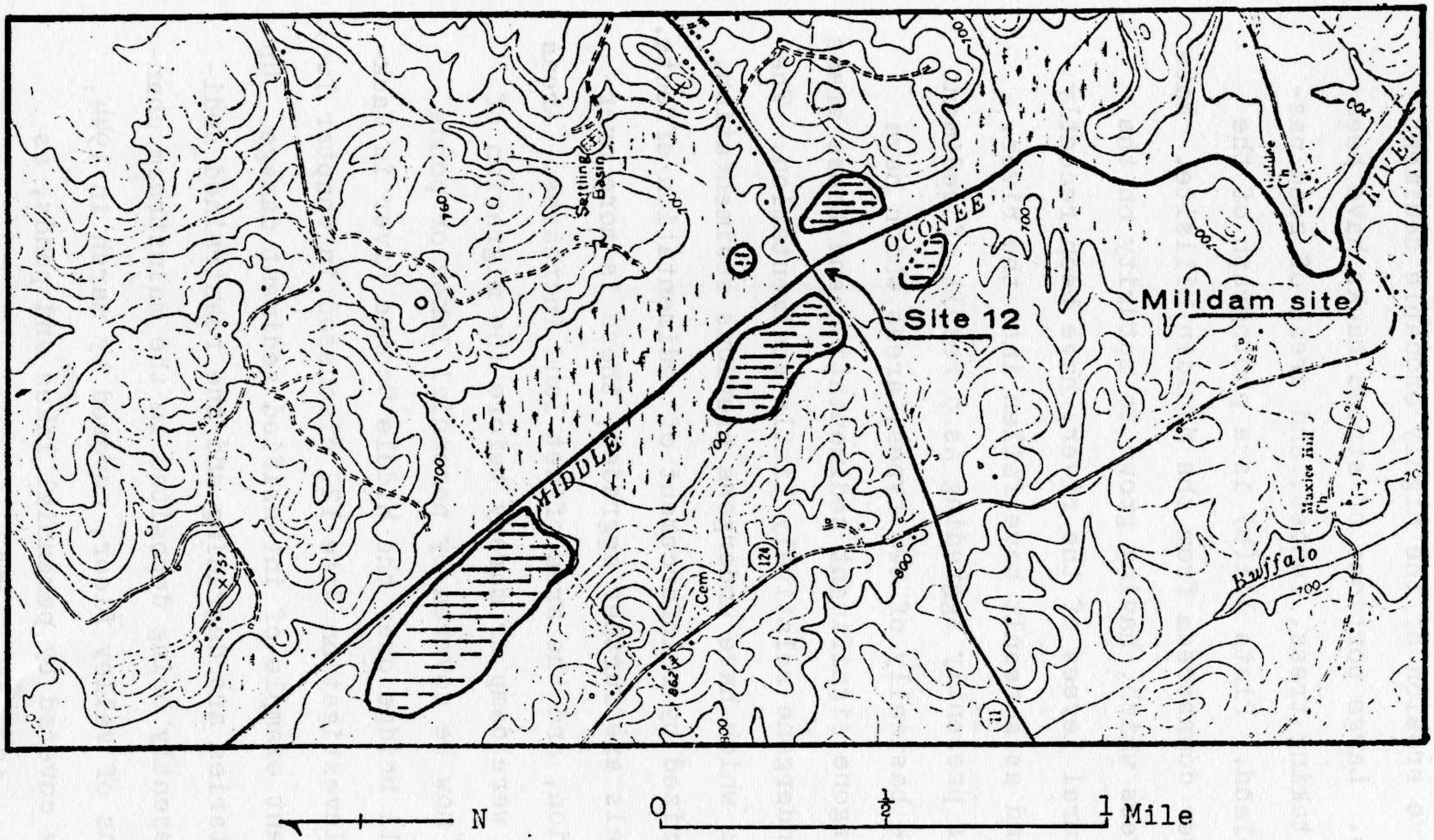


Figure 18. Investigation Site 12 Showing Enlarged and Recently Formed Lakes and Ponds. Scale 1:24,000. Base Map: U. S. Geologic Survey Topographic Maps, Jefferson, Georgia, 1:24,000, 1964. Pond and lake data taken from U.S.D.A. Aerial Photographs: ATN (Jackson County, Georgia), 3HH-162 and 163, January 29, 1967.

PLATE IV

PLATE IV.--West Bank of Middle Oconee River, Upstream from Highway 11 Bridge, Jackson County. Note the large pond in the background which has been formed in the past few years. The dead trees in the foreground were evidently killed by the rising water level.

bridge looking upstream at the west bank. Note the large pond in the background and the dead trees in the foreground evidently killed by the rising water level. The amount of aggradation in recent years has not been determined; but, as shown in Figure 19, there has been six feet of aggradation since 1928.

Several areas which have previously undergone relatively little sedimentation are now being affected by sediment migration. Here, channels are being filled, there is some overbank deposition, and, in a few areas, one may see the beginning of wet lands along the valley floors. These areas which are undergoing sedimentation for the first time because of sediment migration are presently relatively small. Because these areas are along larger streams where more extensive valley lands are present, the future problem could be serious if present processes continue.

In summary, erosion has been greatly reduced in the Study Area during the past thirty-five years. The acreages of row crops have been decreasing since about 1920, until there is presently only 3 to 4 per cent of the Study Area in row crops. The acreage of conservatory crops has been increasing since about 1925 until presently, 80 per cent of the Study Area is under forest, pasture, or lespedeza. The efforts of the Soil Conservation Service in halting soil erosion both on cultivated fields and on abandoned land have been indispensable. Especially valuable was the control of large gullies. Increased stream competency, as a result of

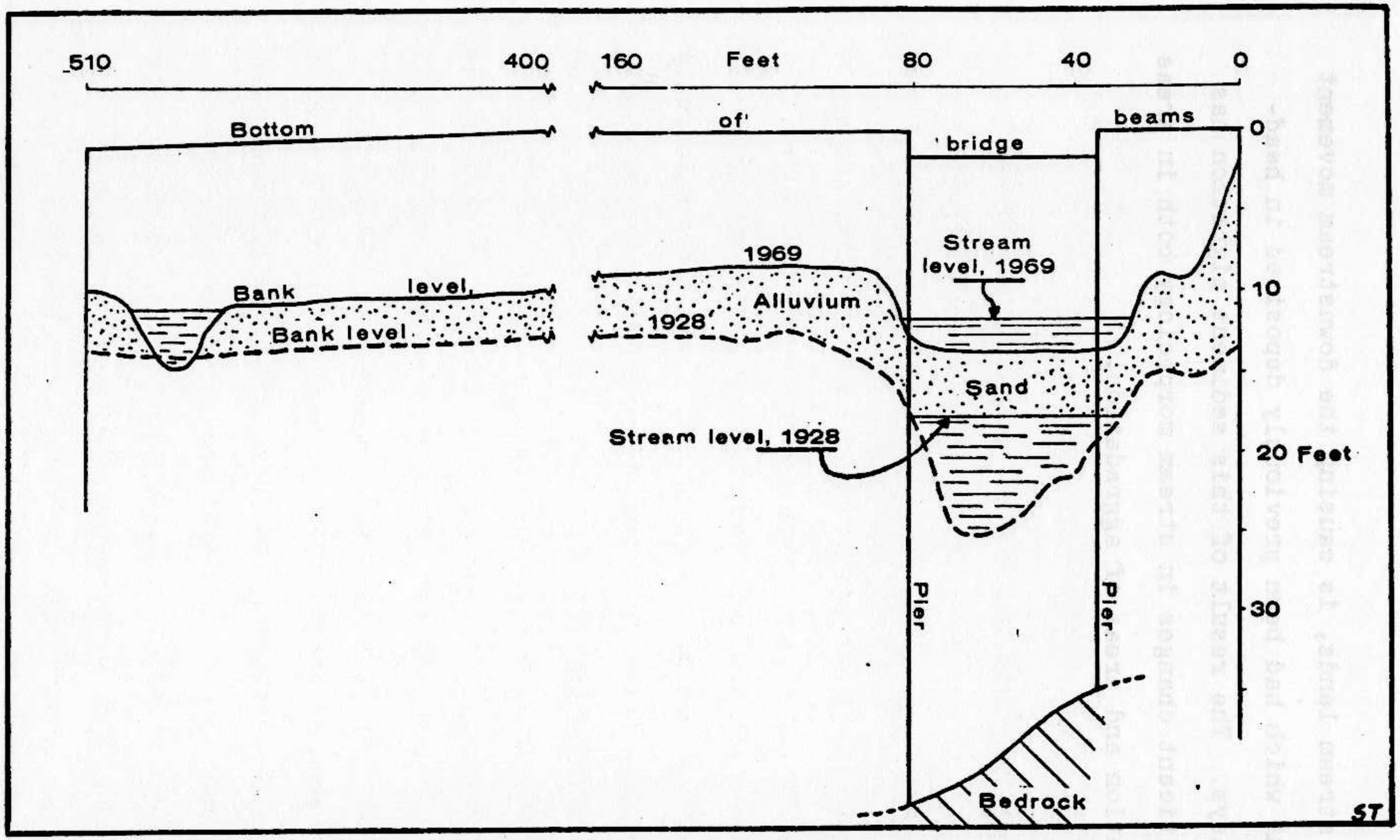


Figure 19. Transverse Profile of the Middle Oconee River at the Highway 11 Bridge, Jackson County. Investigation Site 12. Bridge Plan: Winder-Jefferson Bridge Over Oconee River, Jackson County, Project G-2-59, 1928.

decreased stream lands, is causing the downstream movement of sediment which had been previously deposited in headwater valleys. The result of this sediment migration has been significant changes in stream morphology both in areas of degradation and areas of aggradation.

NOTES

[1]Much of the information concerning the Soil Conservation Service was furnished by Mr. Dan Searcy, Assistant State Conservationist, Athens, Georgia.

[2]Sandy Creek News, (Mimeographed news letter printed by the Soil Conservation Service in Athens, Georgia) Vol. I, (November, 1934), p. 8.

[3]Interview with Mr. Sam Dunaway, Barrow County Soil Conservation Agent, February, 1969.

[4]Frank A. Albert and Albert H. Specter, "A New Song on the Muddy Chattahoochee," Water, The Yearbook of Agriculture, 1955, U. S. Department of Agriculture, (Washington: 1955), p. 209.

[5]Interview with Mr. Ralph Carter of the Athens, Georgia, water plant, June, 1969. Turbidity rates at Athens for dates earlier than 1960 are not available.

[6]Stafford C. Happ, et al, Some Principles of Accelerated Stream and Valley Sedimentation, U. S. Department of Agriculture Technical Bulletin No. 695, (Washington: 1940), p. 94.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

When the first European settlers came into the upper Oconee River Watershed during the period from about 1780 to 1805, they found a stream morphology much different from that of the present. Streams then had definite channels, and stream beds were often rocky. Most valley floor land, although low and subject to overflow in some cases, was perennially dry enough to be cultivated. Bottom land, in fact, was the chief farming area in the early development of much of the Study Area.

Culturally accelerated erosion was started by the initial clearing of land in the early nineteenth century and accentuated locally by plantation agriculture in the middle 1880's. There was little significant change in valley morphology, however, until near the end of the nineteenth century when significant sedimentation began to appear in some low-gradient stream channels and in a few millponds. The appearance of sediment in the streams coincided with a great increase in acreages of row crops, especially cotton, and with a decrease in the acreage of forests. The increasing amount of sediment transported by streams, much of it coarse and sandy, soon filled many stream channels.

As a result of aggraded stream channels, much of the stream discharge was able to flow beneath the surface through the sandy channel deposits. Surface discharge was significantly reduced in many streams, especially during periods of low stream discharge. Aggraded stream channels also caused an increase in the frequency and magnitude of overflows, frequently resulting in the scouring of the clean-cultivated, fertile alluvial soils. An almost ubiquitous consequence of overflows was the deposition of less fertile modern sediment along the valley floors, often in deposits of considerable depth. Occasionally, a stream channel completely clogged so that even the normal stream flow was forced to create new channels along the valley floor.

Because the bulk of the sediment was deposited near the point of overflow, the land along the bank was built up more rapidly than land at some distance from the stream. Consequently, water which overflowed this natural barrier, or levee, either remained ponded or slowly flowed along the valley floor until it could return to the channel through a ditch or stream tributary. Often, the stream bed and natural levees were aggraded until the stream was at a higher level than the valley floor, permanently inundating valley floors. Thus, in the course of a few years, the morphology of many Study Area valleys underwent drastic changes.

Much of the fertile alluvial land along stream valleys was lost to cultivation and constituted a grave economic problem to farmers who had depended heavily on the fertility and dependable moisture of these bottom lands. Bottom lands had most often been used for subsistance crops, especially corn, and for pasture. Landowners often formed drainage associations so that the newly formed wet lands might be reclaimed. These projects, financed by the landowners themselves, attempted to drain the wet areas by straightening and deepening stream channels. These expensive endeavors were largely unsuccessful because erosion, the source of the sediment, was undiminished. Also, the base level of the stream was lowered as a result of the ditching, thus causing sediment deposits in tributary streams to be reentrained and transported to the ditched stream where they were then redeposited. The usual result was that the new channel filled within a short time and usually continued to aggrade. The landscape of the Study Area bears the scars of these drainage projects in the form of anomalously straight stream channels with a few cut-off remnants of the old meandering stream channel to either side of the new channel.

Another consequence of accelerated sedimentation was the filling of millponds and other water-power reservoirs. Millponds were especially susceptible to being filled with this sediment. Many mill owners were simply overwhelmed by the tremendous amount of sediment and abandoned their mills.

Other mill owners, in areas of less sedimentation or in more favorable locations, were able to continue operation for several years by continually draining their millponds. Sedimentation imposed an additional hardship on many mill operations which were already economically marginal, causing them to close. The demise of these water-powered mills was a hardship not only on the owners and operators but also on the rural community to whose economy they contributed.

An infrequent result of stream channel aggradation was the reduction of area of opening under bridges until, in several instances, bridges had to be removed or rebuilt at a higher level. Only a few bridges, all in the northwestern portion of the Study Area, were impaired by sedimentation.

The acreages of land planted to clean-cultivated crops increased greatly from 1890 to <u>circa</u> 1920. Since much of the bottom land was, because of sedimentation, already unavailable for corn, this subsistance crop also had to share the limited gentle slopes on the Piedmont interfluves with the increasing acreages of cotton. Also competing for the more gentle slopes were farmsteads, roads, orchards, and other crops. The increase of cotton growing continued until, in 1919, some counties had more than half of the total land area in corn and cotton. Consequently, farmers were forced to utilize the greater slopes for row crops, generally without the benefit of modern conservation methods.

The Study Area is located in the middle Georgia Piedmont, an area of deeply weathered, easily eroded, saprolitic soils, frequent steep slopes, and intense rainfall. Thus, a combination of extensively cleared land cropped to cotton and corn, steep slopes, erodable soils, intense rainfall, and poor soil conservation practices all joined to allow erosion and consequent sedimentation to increase at an increasing rate. The result of this accelerated sedimentation was the changes in valley morphology which have already been described.

Cotton acreages were drastically reduced from about the year 1920 onward because of boll weevil attacks and adverse economic conditions. The resulting lack of economic opportunity caused many farmers, especially tenants, to abandon their land, much of which eroded and gullied. The gullying was especially significant to sedimentation because the coarse particles of the saprolitic subsoil were transported to streams where the lower water velocity allowed prompt deposition. It was during this era of land abandonment that much severe sedimentation took place. Severe erosion and gullying was still extensive in the middle 1930's when the U. S. Department of Agriculture Soil Conservation Service started operations. The role of the Soil Conservation Service in reducing the erosion and consequent sedimentation of streams in the Study Area is difficult to overestimate. It can safely be stated that without the efforts of the Soil Conservation Service, sedimentation in the Study Area streams would have been far greater. Had the sedimentation rates of the 1920's continued until the present, the results would have been catastrophic; highway bridges would have been literally buried, and wet land would be measured in square miles rather than in acres.

The approximate pattern of distribution of culturally accelerated sedimentation in the Study Area was arrived at by a consideration of the distribution of such criteria as extent of wet land, drainage projects, filled millponds, and reservoirs. Also considered was additional information such as personal observation, county soil surveys, available topographic map coverage, aerial photographs, and interviews with knowledgeable people. After showing the close spatial relationship between erosion and sedimentation, the distribution of sedimentation was explained by considering the distributions of erosional factors. The factors of erosion are those of the soil-loss prediction equation evolved by the U. S. Department of Agriculture, Agricultural Research Service, which include rainfall, soil erodability, length and degree of slope, land use, and conservation practices. Deposition factors such as milldams and reservoirs, low stream gradients, natural debris in the streams, and stream order dominance were also considered.

The distribution of sedimentation seems to have been most influenced by type and extent of land use, a conclusion which tends to reinforce previous non-geographical studies. Secondary erosional factors appear to be rainfall, variation in soil erodability caused by previous erosion, and the proportion of land area in steep slopes. The result of the spatial variation of implemented soil conservation practices was a modification of the effects of erosive land use. Depositional factors such as milldams and reservoirs, natural debris in the streams, and low stream gradients all seemed to have a mainly local effect. Their effect on the overall distribution was relatively minor.

The distribution of sedimentation has begun to change in the past few years and could continue to change in the future at an increasing rate. As was noted throughout Chapter Four, many headwater streams, which underwent intensive sedimentation in the past, are beginning to degrade themselves. The reason for this degradation is the almost complete disappearance of clean-cultivated crops and the present preponderance of conservatory crops, especially forests. Equally important are implemented conservation measures, particularly on cleared and cultivated land. Especially important have been soil erosion control measures on abandoned or severely eroding land. The diminished erosion has resulted in much clearer streams as evidenced by greatly reduced turbidity rates.

The reduced sediment load of headwater streams has increased their competence, and they are reentraining previously deposited sediment and transporting it further downstream where it is redeposited. This sediment migration process is greatly aided by the fact that the sediment deposits in the headwater streams became unstable as stream sediment loads were reduced, and stream equilibrium is now in the process of being restored.

There are several significant effects of this sediment migration. Valley floors along degrading streams may now be easily drained and overflows are generally less likely. Since stream erosion is lateral as well as vertical, large portions of stream banks have been eroded away taking trees, fences, and areas of good pasture or cropland. Areas presently aggrading are basically of two types, areas which have already undergone significant sedimentation and those areas which have undergone relatively little sedimentation. In the former, areas which have undergone previous sedimentation, the effects of sedimentation are reinforced. Stream channels are further aggraded, there is more overbank deposition, and the area of wet land increases. Areas which simply were damp or marshy before the recent migration of sediment may now be covered by perennial lakes or ponds.

In areas which have previously undergone relatively little sedimentation and are now being affected by sediment migration, channels are being filled, there is some overbank deposition, and in a few areas, one may see the beginning of wet lands along the valley floors. Because these areas are along larger streams where more extensive valley lands are present, the future problem could be serious if present processes continue.

The future effects of sediment migration should become the object of interest and research. Of especial interest should be the effects of the present Soil Conservation Service Small Watershed Program in relation to sediment migration. It will be of significance to determine, for example, what effects the Program's runoff retention dams will have on sediment migration. The dams, on the one hand, would tend to even out stream discharge and thus perhaps reduce sediment migration during periods of high discharge. On the other hand, the dams would reduce sediment load, increase stream competency, and perhaps increase sediment migration. Sand removal from stream beds for commercial uses should help control the effects of sediment migration. When redeposition of sediments in any one area is adjudged to be excessive, the state or county involved might subsidize sand removal if necessary.

The phenomena associated with culturally accelerated sedimentation, their causes, and the changes in landscape considered in this study are obviously of interest to geographers, particularly to geomorphologists. There has been some consideration of culturally accelerated erosion and sedimentation in geological publications, but geographers seem to be generally uninterested in the problem. Geomorphology and physiography textbooks appear to have largely ignored both erosion and sedimentation on the Southern Piedmont.[1] The bulk of work accomplished in the study of culturally accelerated sedimentation has been done by investigators from the various sub-fields of agriculture. Many of these investigators have been sponsored by the U. S. Department of Agriculture.

There are probably few man-land relationships more closely linked than land use and culturally accelerated sedimentation. Rarely have natural landscape changes come about so rapidly as have been described in this study. Geomorphologic changes which normally occur over thousands of years have taken place in less than two centuries. As noted in the Introduction, the problem is not limited to the Southern Piedmont but is widespread throughout the United States, especially the eastern United States. Geographers, especially geomorphologists, should take cognizance of the accelerated sedimentation phenomena and combine them into the regional literature. While this study has resulted in a thorough examination of culturally accelerated sedimentation in the Study Area, the extent of area studied was necessarily limited. Further studies of this type in other areas would add much to our knowledge of the consequences of culturally accelerated sedimentation. It is hoped that such further studies might take the form of interdisciplinary endeavors. The geologist, botanist, zoologist, and agricultural scientist, as well as the geographer, all have an interest in these landscape changes which have been described.

NOTES

[1]Wallace W. Atwood, The Physiographic Provinces of North America, (Boston: 1940). N. M. Fenneman, Physiography of the Eastern United States, (New York: 1938). Charles B. Hunt, Physiography of the United States, (San Francisco: 1967). William D. Thornbury, Regional Geomorphology of the United States, (new York: 1965).

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Gillsville, Georgia.

Gray, Georgia.

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Hull, Georgia.

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